NASA SP-7037 (322)
October 1995

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

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AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

National Aeronautics and Space Administration
Scientific and Technical Information Office
Washington, DC 1995

INTRODUCTION

This issue of *Aeronautical Engineering — A Continuing Bibliography with Indexes* (NASA SP-7037) lists 719 reports, journal articles, and other documents recently announced in the NASA STI Database.

Accession numbers cited in this issue include:

Scientific and Technical Aerospace Reports (STAR) (N-10000 Series)	N95-28678 — N95-30357
Open Literature (A-60000 Series)	A95-86772 — A95-92370

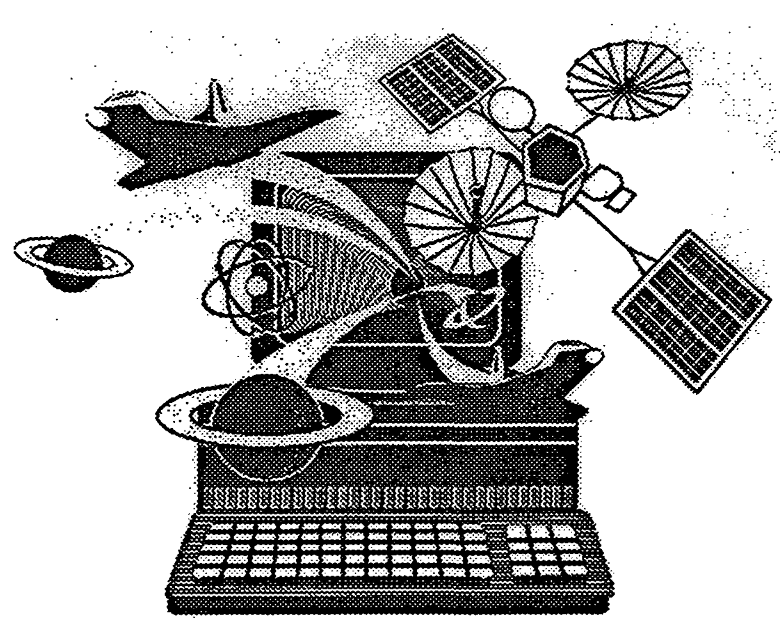
The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the publication consists of a standard bibliographic citation accompanied, in most cases, by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals.

Seven indexes—subject, personal author, corporate source, foreign technology, contract number, report number, and accession number—are included.

A cumulative index for 1995 will be published in early 1996.

The NASA CASI price code table, addresses of organizations, and document availability information are located at the back of this issue.



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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED
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ACCESSION NUMBER →	N95-10318*# Dow Chemical Co., Midland, MI.	← CORPORATE SOURCE
TITLE →	**NOVEL MATRIX RESINS FOR COMPOSITES FOR AIRCRAFT PRIMARY STRUCTURES, PHASE 1 Final Report, Apr. 1989 - Mar. 1992**	
AUTHORS →	EDMUND P. WOO, P. M. PUCKETT, S. MAYNARD, M. T. BISHOP, K. J. BRUZA, J. P. GODSCHALX, AND M. J. MULLINS Aug. 1992 164 p	← PUBLICATION DATE
CONTRACT NUMBERS →	(Contracts NAS1-18841; RTOP 510-02-11-02)	
REPORT NUMBERS →	(NASA-CR-189657; NAS 1.26:189657) Avail: CASI HC A08/MFA02	← AVAILABILITY AND PRICE CODE

The objective of the contract is the development of matrix resins with improved processability and properties for composites for primarily aircraft structures. To this end, several resins/systems were identified for subsonic and supersonic applications. For subsonic aircraft, a series of epoxy resins suitable for RTM and powder prepreg was shown to give composites with about 40 ksi compressive strength after impact (CAI) and 200 F/wet mechanical performance. For supersonic applications, a thermoplastic toughened cyanate prepreg system has demonstrated excellent resistance to heat aging at 360 F for 4000 hours, 40 ksi CAI and useful mechanical properties at greater than or equal to 310 F. An AB-BCB-maleimide resin was identified as a leading candidate for the HSCT. Composite panels fabricated by RTM show CAI of approximately 50 ksi, 350 F/wet performance and excellent retention of mechanical properties after aging at 400 F for 4000 hours. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ACCESSION NUMBER →	A95-60192* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.	← CORPORATE SOURCE
TITLE →	**AERODYNAMIC INTERACTIONS BETWEEN A ROTOR AND WING IN HOVER**	
AUTHORS →	FORT F. FELKER NASA. Ames Research Center, Moffett Field, CA, US and JEFFREY S. LIGHT NASA. Ames Research Center, Moffett Field, CA, US	← AUTHOR'S AFFILIATION
	Journal of the American Helicopter Society	← JOURNAL TITLE
PUBLICATION DATE →	2 Jun. 1986 p. 53-61	
REPORT NUMBER →	(HTN-94-00714) Copyright	

An experimental investigation of rotor/wing aerodynamic interactions in hover is described. The investigation consisted of both a large-scale and a small-scale test. A 0.658-scale V-22 rotor and wing was used in the large-scale test. Wing download, wing surface pressure, rotor performance, and rotor downwash data from the large-scale test are presented. A small-scale experiment was conducted to determine how changes in the rotor/wing geometry affected the aerodynamic interactions. These geometry variations included the distance between the rotor and wing, wing incidence angle, wing flap angle, rotor rotation direction, and configurations both with the rotor axis at the tip of the wing (tilt rotor configuration) and with the rotor axis at the center of the wing (compound helicopter configuration). Author (Herner)

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 322)

October 1995

01 AERONAUTICS (GENERAL)

A95-88897

VORTEX DRIFT: A HISTORICAL SURVEY

NICHOLAS ROTT *In* Symposium on Aerodynamics & Aeroacoustics, Tucson, AZ, March 1-2, 1993. A95-88892 Singapore World Scientific Pub. Co. Pte. Ltd. (Advanced Series on Fluid Mechanics) 1994 p. 173-186
Copyright

The history of vortex theory began in 1858 with the seminal treatise of Helmholtz. He established the foundations of vortex dynamics in two and three dimensions. This paper continues on this subject of free vortex regions, and their potential to drift, by reconsidering the problem through its historical roots. Herner

A95-89634

MATERIALS AND STRUCTURES FOR THE HSCT

ALEX VELICKI McDonnell Douglas Aerospace Aerospace Engineering (Warrendale, Pennsylvania) (ISSN 0736-2536) vol. 15, no. 4 April 1995 p. 17-19
(BTN-95-EIX95282711241) Copyright

Funded by NASA, engineers at McDonnell Douglas Aerospace are considering various structural design issues and materials for High-Speed Civil Transport program. The objective of the program dictates that the airframe's structural performance increase considerably beyond conventional aluminum skin/stringer designs. Structural weight fractions of 25%, common for 300-passenger subsonic airframes must be reduced to less than 20% to attain the goals set forth for the HSCT. To achieve a 20% structural weight reduction, material and structural concept selection must be driven toward higher risk/payoff designs. EI

A95-89640

REDUCED-ORDER NONLINEAR ANALYSIS OF AIRCRAFT DYNAMICS

GERARD LENG Natl Univ of Singapore, Singapore Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 18, no. 2 March-April 1995 p. 361-364 refs
(BTN-95-EIX95282706665) Copyright

Results from nonlinear dynamical systems theory are used in understanding flight dynamics at large angles of attack and sideslip. For flight in this regime traditional methods of stability analysis based on linear systems theory are of limited use. This is especially so in the identification of postcritical behavior. Instabilities encountered at large angles of attack and sideslip such as pitch-up, noseslice, and wing-rock are readily examined within the context of bifurcation theory. Examples of nonlinear analysis using reduced-order models and a combined symbolic/numerical computational approach are discussed and the robustness of the bifurcations to unmodeled dynamics is examined. Author (EI)

A95-89663

PRELIMINARY STUDY ON THE FIXED TRANSITION TECHNIQUE FOR A SHOCK TUBE TRANSONIC AIRFOIL FLOW

YUTAKA YAMAGUCHI Natl Defense Acad, Yokosuka, Japan and TARO AMEMIYA Transactions of the Japan Society for Aeronautical and Space Sciences (ISSN 0549-3811) vol. 37, no. 118 February 1995 p. 311-318 refs
(BTN-95-EIX95282705928) Copyright

The fixed transition technique, often used in conventional wind tunnel testings, was tried in a shock tube transonic flow with an NACA 0012 airfoil. Tests were performed by placing scotch tapes of 0.06 mm thickness on the surface of the airfoil as the trip strip, and the flow field was observed with schlieren method, and the boundary layer transition was confirmed by the profile of the main shock wave. The hot gas Mach number and Reynolds number based on the chord length were 0.84 and 0.39 million, respectively. It was revealed that the original two dimensional tape did not work properly as a trip strip because relatively strong compression waves were formed at the strip. Various configurations of the strip were tested to weaken the waves produced at the tape position and to get the desirable main shock profile on the surface of the airfoil. From these tests, it was found that the fixed transition technique is applicable to such a shock tube airfoil flow, and the optimum fixed transition for the shock tube airfoil flow could be obtained by placing 12 pieces of the tape of 2.5 mm spanwise, 0.5 mm chordwise, and 0.06 mm in thickness at the 5% chord position. Author (EI)

A95-89664

NONLINEAR ANALYSIS OF THE GORTLER INSTABILITY

NOBUTAKE ITOH Natl Aerospace Lab, Tokyo, Japan Transactions of the Japan Society for Aeronautical and Space Sciences (ISSN 0549-3811) vol. 37, no. 118 February 1995 p. 278-290 refs
(BTN-95-EIX95282705926) Copyright

A model system of ordinary differential equations is used as an approximation to the partial differential system governing a small-disturbance with spanwise periodicity superimposed on a two-dimensional laminar boundary layer along a concave wall. The linearized version formulates a simple modification of the well-known Gortler equations, including an additional term associated with non-parallelism of the basic flow. The additional term plays an important role outside the boundary layer and the modified system yields a neutral stability curve possessing a critical Gortler number at a finite value of spanwise wavenumber. The formulation is extended to the weakly nonlinear theory to evaluate the Landau coefficients. A new type of singularity is found, which is due to a resonance between the fundamental Fourier component and the second harmonic of disturbances in a supercritical region slightly above the linear critical point. Weakly nonlinear analysis of the resonance indicates very strong growth of the two Fourier components. This fact offers a plausible explanation to the wavenumber selection of disturbances observed in experiments. Author (EI)

A95-89667

CORRECTIVE TERM IN WALL SLIP EQUATIONS FOR KNUDSEN LAYER

REMY GONIAK Commissariat a l'Energie Atomique, Le Barp, France and GEORGES DUFFA Journal of Thermophysics and

ABSTRACTS

Heat Transfer (ISSN 0887-8722) vol. 9, no. 2 April-June 1995 p. 383-384 refs
(BTN-95-EIX95282705070) Copyright

A reentry vehicle along its trajectory through the atmosphere encounters various aerodynamics regimes with decreasing altitude; rarefied regime, transition, and continuum. The transition regime which is characterised by slip conditions on the vehicle wall can be computed by: (a) coupling the continuum method and direct simulation and (b) by using slip conditions as boundary conditions. In resuming the Gupta et al. and Grad calculations for a monoatomic gas, several errors were found. The corrections lead to a supplementary term in the temperature jump. The present investigation deals with the simple monodimensional flow problem between two parallel plates. EI

A95-90080

AIRCRAFT WIRING MAINTENANCE: DEVELOPMENT OF A COMPUTERIZED MAINTENANCE AID

MATHIAS L. KOLLECK Booz, Allen & Hamilton, Inc., US (ISSN 0148-7191) 1993 11 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932615; HTN-95-A1505) Copyright

The electrical wiring systems of modern aircraft are extremely complex and, therefore, very difficult to assess and repair quickly. These difficulties will only increase as more sophisticated aircraft are fielded with advanced technologies providing increased capabilities, which will increase the number of wires required. To help overcome these difficulties, a working prototype of a computerized manitenance aid has been developed under government contract for the U.S. Air Force. Field tests have shown significant reductions in diagnostic/repair times and in skill levels required to perform work. This tool has the potential to help airlines reduce the time and cost of wiring related maintenance activities. Furthermore, this concept can be extrapolated to other systems within an aircraft (e.g., fuel, hydraulics, environmental control) as well as ships and ground vehicles, including automobiles. With the increasing complexity of automobile electrical systems, this concept could also be applicable to automobile maintenance. Author (Herner)

A95-90081

USE OF STARCH BASED BLAST MEDIA FOR DRY PAINT STRIPPING

ROBERT A. PAULI Pauli & Griffin Co., US (ISSN 0148-7191) 1993 6 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932616; HTN-95-A1506) Copyright

In the 1980's, several processes emerged as possible replacements for chemical strippers containing methylene chloride. A viable process appears to be dry mechanical stripping using wheat starch. It is seen as promising because of its gentle treatment of aluminum alloys and composites. The process itself is reported to be operator friendly, with no fiber or primer damage even with multiple blast cycles. The media has been tested by Boeing Commercial Airplane Co. and is in production use at Beech Aircraft Corp. and Hunting Aircraft. Boeing reports that microscopic examination has shown wheat starch blasting to be smoother and less damaging to fibers compared to hand sanding. Starch blasting leaves a smooth finish on aluminum, bare or clad, and can strip aluminum skins as thin as 0.016 in. without deformation. The media is soft and forgiving and does not cause crack closure or smearing on aluminum alloys. Testing at Pauli & Griffin's facility is continuing in a joint United Airlines/Boeing/Douglas program on stripping composite substrates and should be completed using wheat starch is expected from Boeing in the spring of 1993. Plastic media currently has a single strip approval. Author (Herner)

A95-90082

MAINTENANCE TRAINING TO COPE WITH HIGH-TECH INNOVATIONS

DOUGLAS M. GRANT Continental Airlines, US (ISSN 0148-7191) 1993 3 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932619; HTN-95-A1507) Copyright

High technology advances in new aircraft systems have expanded the training requirements for these aircraft and increased both labor and material costs. A logical reaction within the training community has been to modularize the training package; and to identify the client, trainee-force in levels of skill and training needs. There is a constructive movement of increased participation between manufacturers and airline training departments, and improved coordination and self-empowerment in both the airlines pilots and mechanic ranks. We also should recognize improvements in training media, such as Computer-Based-Training that 'Brings the aircraft into the classroom', and provides improved training methods. The purpose of this paper is to share the evolution of the training process as it changed in reaction to the high technology training requirements. Author (revised by Herner)

A95-90756

TRENDS IN AEROSPACE FORGINGS IN THE 1990S

SULEKH C. JAIN G.E. Aircraft Engines, Cincinnati, Ohio, US and BRUCE P. BARDES Miami University, Oxford, Ohio, US JOM (ISSN 1047-4838) vol. 46, no. 5 May 1994 p. 49-53
(HTN-95-B0408) Copyright

In the 1990s, forgings require computer-aided design and manufacturing, process modeling, cleaner forging materials, better control of forging and related processes, and closer cooperation between supplier and customer. Forgers will have to employ more sophisticated forging and sensing and control equipment to better meet the demands of close tolerances and increasingly difficult-to-forge materials. Customers will continue to place higher emphasis on quality that remains consistently high. This article examines trends in aerospace forgings that will affect forgers, equipment and materials suppliers in the 1990s. Most of these trends are virtually certain to occur; indeed, some have already begun. What is less certain is the degree to which these trends will occur, and the rapidity of their occurrence. Author (revised by Herner)

A95-91501

EXPERIENCE OF AIRCRAFT MANUFACTURER FOR PAINT REMOVAL USING DRY STRIPPING METHOD

SEIICHI MIZOGUCHI FHI, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 72-75 In JAPANESE
Copyright

Several non-chemical paint removal methods for aircraft are now developing around the world. Dry stripping that uses plastic media to remove paint on aircraft surface is one of these new paint removal technologies. Fuji Heavy Industry Ltd. Aerospace Division has developed dry stripping equipment for actual use. The experience of paint removal using dry stripping and future application plans for aircraft are introduced in this report. Some technical issues to be solved are also included. Author (Herner)

A95-91703

FAULT DIAGNOSIS FOR CONDITION MONITORING APPLIED TO HYDRAULIC CIRCUITS

D. J. WOOLONS University of Exeter, UK, R. M. ATKINSON University of Exeter, UK, K. D. A. PILLAY University of Exeter, UK, C. R. BURROWS University of Bath, UK, P. A. HOGAN University of Bath, UK, and K. A. EDGE University of Bath, UK 1991 6 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 12: Health and Condition Monitoring for Fixed Wing Aircraft)
(CONGRESS PAPER C428-12-165; HTN-95-21134) Copyright

Expert systems for fault diagnosis tend to be based on shallow, heuristic knowledge. For success in engineering applications, it is argued that knowledge of the underlying principles should be modeled. An object-oriented software library representing hydraulic components is being built. This will be re-usable to construct an expert system for the analysis of any arbitrary hydraulic circuit. Author (Herner)

A95-91704
HEALTH MONITORING AND COST IMPLICATIONS FOR AN AIRLINE OPERATOR
A. C. BISSON Brittania Airways Ltd, UK and D. H. MERCER Brittania Airways Ltd, UK 1991 6 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 12: Health and Condition Monitoring for Fixed Wing Aircraft)
(CONGRESS PAPER C428-12-166; HTN-95-21135) Copyright

Health monitoring in the airline industry covers one of the many aspects of the maintenance and airworthiness control which is incumbent upon the operator to observe. Whether its application is to systems components or aircraft structures it should contribute to historic and real time data. To be cost effective it should detect and arrest deterioration allowing restoration programs to be undertaken without jeopardizing airworthiness and safety. With new information and technology a unique opportunity exists to offer new concepts in the discipline of health monitoring. This presentation will cover the views of a charter operator on some of the current practices and methodology and to potential future developments. Author (Herner)

A95-91711
ROLLING BEARING FAILURE AND WEAR DEBRIS DETECTION
P. D. COOPER 1991 12 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 15: Propulsion 1 Wear Detection)
(CONGRESS PAPER C428-15-094; HTN-95-21142) Copyright

The advantages of being able to monitor the condition of expensive capital machinary while it is in operation have served as a spur towards improving understanding of the various technologies involved. Monitoring the state of bearings is often one of the prime activities and it was a scarcity of information which led to collaborative work between RHP Bearings and MOD (PE) in this area. The aims of this present work were: (1) to design and build a test rig suitable for condition monitoring roller bearings; (2) to evaluate commercial debris monitors; and (3) to investigate the debris information being supplied by roller bearings as they fail. Author (Herner)

A95-91713
DEVELOPMENTS IN WEAR PARTICLE ANALYSIS USING COMPUTERISED PROCEDURES
B. J. ROYLANCE University College of Swansea, UK 1991 7 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 15: Propulsion 1 Wear Detection)
(CONGRESS PAPER C428-15-216; HTN-95-21144) Copyright

Against the background of evolutionary changes taking place in maintenance-related activities the role of wear particle analysis is reviewed with particular reference to the scope for utilizing computerized procedures. Some recent developments are described and the implications for their implementation as part of condition-based predictive maintnance procedures are discussed. Author (Herner)

A95-91720
THE USE OF MATH-DYNAMIC MODELS TO AID THE DEVELOPMENT OF INTEGRATED HEALTH AND USAGE MONITORING SYSTEMS
H. AZZAM and M. J. ANDREW 1991 6 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 19: Rotorcraft)
(CONGRESS PAPER C428-19-079; HTN-95-21151) Copyright

Development of Integrated Health and Usage Monitoring Systems (IHUMS) involved the use of personal computer-based math-dynamic models, which in this particular case simulate a range of helicopter rotor system faults and potentially catastrophic failures. Using both theoretical and infield data over 120 fault cases have been analysed to identify discriminatory characteristics. This paper reports on the background of the math-dynamic models and the findings of the diagnostic analysis. Author (Herner)

N95-28816*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
INVESTIGATION OF WING UPPER SURFACE FLOW-FIELD DISTURBANCE DUE TO NASA DC-8-72 IN-FLIGHT INBOARD THRUST-REVERSER DEPLOYMENT
HEDAYAT U. HAMID, RICHARD J. MARGASON, and GORDON HARDY Jun. 1995 63 p
(Contract(s)/Grant(s): RTOP 505-59-53)
(NASA-TM-110351; A-950060; NAS 1.15:110351) Avail: CASI HC A04/MF A01

An investigation of the wing upper surface flow-field disturbance due to in-flight inboard thrust reverser deployment on the NASA DC-8-72, which was conducted cooperatively by NASA Ames, the Federal Aviation Administration (FAA), McDonnell Douglas, and the Aerospace Industry Association (AIA), is outlined and discussed in detail. The purpose of this flight test was to obtain tufted flow visualization data which demonstrates the effect of thrust reverser deployment on the wing upper surface flow field to determine if the disturbed flow regions could be modeled by computational methods. A total of six symmetric thrust reversals of the two inboard engines were performed to monitor tuft and flow cone patterns as well as the character of their movement at the nominal Mach numbers of 0.55, 0.70, and 0.85. The tufts and flow cones were photographed and video-taped to determine the type of flow field that occurs with and without the thrust reversers deployed. In addition, the normal NASA DC-8 onboard Data Acquisition Distribution System (DADS) was used to synchronize the cameras. Results of this flight test will be presented in two parts. First, three distinct flow patterns associated with the above Mach numbers were sketched from the motion videos and discussed in detail. Second, other relevant aircraft parameters, such as aircraft's angular orientation, altitude, Mach number, and vertical descent, are discussed. The flight test participants' comments were recorded on the videos and the interested reader is referred to the video supplement section of this report for that information. Author

N95-29414# Naval Postgraduate School, Monterey, CA.
AN ANALYSIS OF THE IMPACT OF ASPA ON ORGANIZATIONAL AND DEPOT LEVEL MAINTENANCE M.S. Thesis
ROBERT G. RAMSEY and LEO J. LEGIDAKES Dec. 1994 79 p
(AD-A292670) Avail: CASI HC A05/MF A01

The Aircraft Service Period Adjustment (ASPA) Program was designed to determine the need to induct an aircraft into Standard Depot Level Maintenance (SDLM) based on Period End Date (PED), material condition, flight time and other factors in order to determine if the SDLM could be deferred for one year before reinspection andlor induction. If the SDLM is deferred, the expenditure of depot funds for an aircraft is deferred in the current year. Initially, the program allowed for the extension and deferral of numerous aircraft and did produce a one time saving. However, it has been observed that deferring SDLM, results in the deterioration in aircraft material condition. More over, ASPA brings significant uncertainty in depot parts support and SDLM planning and scheduling. ASPA causes a redundancy of effort in duplicating the aircraft inspections for ASPA and for induction into SDLM. In this research we show that the termination of the ASPA Program will significantly reduce the uncertainty and variability inherent in the Navy depot induction process. With the variability reduced turnaround time, organizational and depot workload, man hours expended and total costs will be improved. DTIC

N95-30229*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LASER DOPPLER VELOCIMETER SYSTEM FOR SUBSONIC JET MIXER NOZZLE TESTING AT THE NASA LEWIS AEROACOUSTIC PROPULSION LAB
GARY G. PODBOY, JAMES E. BRIDGES (NYMA, Inc., Brook Park, OH.), NASEEM H. SAIYED, and MARTIN J. KRUPAR Jun. 1995 30 p Presented at the 31st Joint Propulsion Conference and Exhibit, San Diego, CA, 10-12 Jul. 1995; sponsored by AIAA, ASME, SAE, and ASEE
(Contract(s)/Grant(s): RTOP 538-03-11)

(NASA-TM-106984; E-9753; NAS 1.15:106984; AIAA PAPER 95-2787) Avail: CASI HC A03/MF A01; 4 functional color pages

A laser Doppler velocimeter (LDV) system developed for the Aeroacoustic Propulsion Laboratory (APL) at the NASA Lewis Research Center is described. This system was developed to acquire detailed flow field data which could be used to quantify the effectiveness of internal exhaust gas mixers (IEGM's) and to verify and calibrate computational codes. The LDV was used as an orthogonal, three component system to measure the flow field downstream of the exit of a series of IEGM's and a reference axisymmetric splitter configuration. The LDV system was also used as a one component system to measure the internal axial flow within the nozzle tailpipe downstream of the mixers. These IEGM's were designed for low-bypass ratio turbofan engines. The data were obtained at a simulated low flight speed, high-power operating condition. The optical, seeding, and data acquisition systems of the LDV are described in detail. Sample flow field measurements are provided to illustrate the capabilities of the system at the time of this test, which represented the first use of LDV at the APL. A discussion of planned improvements to the LDV is also included. Author

02
AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A95-87199

TECHNIQUES FOR TAILORING AIRCRAFT STALL AND POST-STALL BEHAVIOR

WILLIAM BIHRLE, JR. (ISSN 0148-7191) 1993 8 p. SAE General, Corporate, & Regional Aviation Meeting & Exposition, Witchita, KS, May 18-20, 1993

(SAE PAPER 931226; HTN-95-42549) Copyright

This paper briefly reviews existing experimental and analytical techniques applied extensively to military configurations operating in stalled flight. As a consequence of these efforts, the fighter flight envelope has been expanded well beyond wing stall without encountering departures from controlled flight. It is now also possible for engineering/mission trainer simulators to calculate all the motions an aircraft is capable of experiencing between -90 deg and +90 deg angle of attack. Exploiting these validated techniques relative to general aviation configurations could greatly influence Industry's future design and training efforts as well as FAA regulations and certification procedures. Author (Herner)

A95-87200

EFFICIENT SENSITIVITY ANALYSIS FOR ROTARY-WING AEROMECHANICAL PROBLEMS

ANNE MARIE SPENCE University of Maryland, College Park, MD, US and ROBERTO CELI University of Maryland, College Park, MD, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 12 December 1994 p. 2337-2344

(Contract(s)/Grant(s): DAAL03-88-C-002; NSF CDR-88-03012)

(HTN-95-42570) Copyright

This paper describes a method for the calculation of the sensitivities of rotating blade root loads and hub loads to changes of blade design parameters using a chain rule differentiation approach. The algorithm eploits features of the formulation of the blade and fuselage equations of motion, and of the solution technique, to calculate the sensitivities at a fraction of the cost of an aeroelastic analysis. The mathematical model of the blade includes nonlinearities because of moderately large elastic deflections and the fuselage is described by nonlinear Euler equations, so that the resulting model is valid for both straight and turning flight. The results indicate that the semianalytical technique is very accurate and computationally efficient. Author (Herner)

A95-87201* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

MACH WAVE EMISSION FROM A HIGH-TEMPERATURE SUPERSONIC JET

JOHN M. SEINER NASA. Langley Research Center, Hampton, VA, US, THONSE R. S. BHAT Old Dominion University, Norfolk, VA, US, and MICHAEL K. PONTON NASA. Langley Research Center, Hampton, VA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 12 December 1994 p. 2345-2350

(HTN-95-42571) Copyright

The paper considers the compressible Rayleigh equation as a model for the Mach wave emission mechanism associated with high-temperature supersonic jets. Solutions to the compressible Rayleigh equation reveal the existence of several families of supersonically convecting instability waves. These waves directly radiate noise to the jet far field. The predicted noise characteristics are compared to previously acquired experimental data for an axisymmetric Mach 2 fully pressure balanced jet operating over a range of jet total temperatures from ambient to 1370 K. The results of this comparison show that the first-order supersonic instability wave and the Kelvin-Hemlhlotz first-, second-, and third-order modes have directional radiation characteristics that are in agreement with observed data. The assumption of equal initial amplitudes for all of the waves leads to the conclusion that the flapping mode of instability dominates the noise radiatio process of supersonic jets. At a jet temperature of 1370 K, supersonic instability waves are predicted to dominate the noise radiated at high frequency at narrow angles to the jet axis. Author (Herner)

A95-87207* National Aeronautics and Space Administration, Washington, DC.

HYPERSONIC FLOW PAST OPEN CAVITIES

ALGACYR MORGENSTERN, JR. North Carolina State University, Raleigh, NC, US and NDAONA CHOKANI North Carolina State University, Raleigh, NC, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 12 December 1994 p. 2387-2393 Research sponsored by the Instituto de Aeronautica e Espaco/CTA

(Contract(s)/Grant(s): NAGW-1331)

(HTN-95-42577) Copyright

The hypersoic flow over a cavity is investigated. The time-dependent compressible Navier-Stokes equations are numerically solved. An implicit algorithm, with a subiteration procedure to recover time accuracy, is used to perform the time-accurate computations. The objective of the study is to investigate the effects of Reynolds number and cavity dimensions. The comparsion of the computations with available experimental data, in terms of time mean static pressure, heat transfer, and Mach number, show good agreement. In the computations large vortex structures, which adversely affect the cavity flow characteristics, are observed at the rear of the cavity. A self-sustained oscillatory motion occurs within the cavity over a range of Reynolds number and cavity dimensions. The frequency spectra of the oscillations show good agreement with a modified semiempirical relation. Author (Herner)

A95-87210

ACTIVE BOUNDARY-LAYER CONTROL IN DIFFUSERS

ANTHONY H. M. KWONG Cambridge University, Cambridge, UK and ANN P. DOWLING Cambridge University, Cambridge, UK AIAA Journal (ISSN 0001-1452) vol. 32, no. 12 December 1994 p. 2409-2414

(HTN-95-42580) Copyright

Flow separation in diffusers leads to loss in energy recovery and is often a source of unsteadiness due to stall movements. This paper investigates the use of wall jets as a remedy to these problems. New jet geometries are compared to the conventional annular blowing. Steady wall jets are found to be capable of raising the mean pressure recovery in both conical and rectangular air diffusers, but high injected mass flow rates are required before the flow in rectangular diffusers becomes steady, Active feedback control is applied to reduce this flow unsteadiness. To implement the control, the air supplied through the wall jets is modulated in response to the unsteady pressures within the diffuser. Results are presented for two feedback mechanisms. Both are found to be effective with the level of attenuation well predicted by theory. A combination of steady and unsteady blowing is found to be capable of giving both a good mean pressure recovery and reduced pressure oscillations. Author (Herner)

A95-87211
NUMERICAL MODEL OF BOUNDARY-LAYER CONTROL USING AIR-JET GENERATED VORTICES
F. S. HENRY City University, London, UK and H. H. PEARCEY City University, London, UK AIAA Journal (ISSN 0001-1452) vol. 32, no. 12 December 1994 p. 2415-2425 Research sponsored by British Aerospace Ltd.
(HTN-95-42581) Copyright

Numerical calculations of the three-dimensional flowfield generated by pitched and skewed air jets issuing into an otherwise undisturbed turbulent boundary layer are presented. It is demonstrated that each such jet produces a single strong longitudinal vortex. The strength of the vortex, as inferred from its effect on the development of skin friction, is shown to be influenced by pitch and skew angles, exit velocity, and downstream distance in ways which accord with published experimental results. The calculated beneficial effect that the longitudinal vortices have on the development of skin friction in an adverse pressure gradient demonstrates the mechanism by which vortex generators delay boundary-layer separation. It follows that the numerical model could be used to optimize arrays of air-jet vortex generators. Furthermore, the facility to quantify the interaction between the vortex and the boundary layer should also be valuable in the application of vane vortex generators, and possible even more generally. Author (Herner)

A95-87212
EIGENANALYSIS OF UNSTEADY FLOWS ABOUT AIRFOILS, CASCADES, AND WINGS
KENNETH C. HALL Duke University, Durham, NC, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 12 December 1994 p. 2426-2432 (HTN-95-42582) Copyright

A general technique for constructing reduced order models of unsteady aerodynamic flows about two-dimensional isolated airfoils, cascades of airfoils, and three-dimensional wings is developed. The starting point is a time domain computational model of the unsteady small disturbance flow. For illustration purposes, we apply the technique to an unsteady incompressible vortex lattice model. The eigenmodes of the system, which may be thought of as aerodynamic states, are computed and subsequently used to construct computationally efficient, reduced order models of the unsteady flowfield. Only a handful of the most dominant eigenmodes are retained in the reduced order model. The effect of the remaining eignemodes is included approximately using a static correction technique. An important advantage of the present method is that once the eigenmode information has been computed, reduced order models can be constructed for any number of arbitrary modes of airfoil motion very inexpensively. Numerical examples are presented that demonstrate the accuracy and computational efficiency of the present method. Finally, we show how the reduced order model may be incorporated into an aeroelastic flutter model. Author (Herner)

A95-87219
EFFECTS OF SPATIAL ORDER OF ACCURACY ON THE COMPUTATION OF VORTICAL FLOWFIELDS
J. A. EKATERINARIS Navy-NASA Joint Institute of Aeronautics, Moffett Field, CA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 12 December 1994 p. 2471-2474
(HTN-95-42589) Copyright

The objective of the present investigation is to assess the effect of the spatial order of accuracy used for the evaluation of the inviscid fluxes on the resolution of higher order quantitites, such as velocity gradients. The viscous terms are computed as second-order accurate with central difference formulas, even though for the explicit part of the algorithm higher order approximations may be used. A viscous/inviscid method is used, and the outer part of the flowfield is computed with the inviscid flow equations. The viscous boundary-layer type flow region close to the body surface is computed with an algebraic eddy viscosity model. Results obtained with the conservative and nonconservative formulations and the viscous/inviscid approach are compared with available experimental data. The effect of grid refinement on the accuracy of the solution is also presented. Author (Herner)

A95-87221
SHOCK TUNNEL MEASUREMENTS OF HYPERVELOCITY BLUNTED CONE DRAG
L. M. PORTER The University of Queensland, St. Lucia, Queensland, Australia, A. PAULL The University of Queensland, St. Lucia, Queensland, Australia, D. J. MEE The University of Queensland, St. Lucia, Queensland, Australia, and J. M. SIMMONS The University of Queensland, St. Lucia, Queensland, Australia AIAA Journal (ISSN 0001-1452) vol. 32, no. 12 December 1994 p. 2476-2477 Research sponsored by the Australian Research Council
(HTN-95-42591) Copyright

Presented here are results obtained from an investigation into the effects of nose bluntness on slender cone drag in the hypervelocity flight regime (flight speeds greater than 5 km/s). Experiments on a 5-deg semi-vertex angle, variable nose tip cone at zero angle of attack were conducted in the T4 free piston driver shock tunnel at a free-stream Mach number of 5.2 and stagnation enthalpy of 14.9 MJ/kg. The drag was measured using the technique developed by Sanderson and Simmons for use in impulse facilities. Author (Herner)

A95-87222* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ENHANCED MIXING OF MULTIPLE SUPERSONIC RECTANGULAR JETS BY SYNCHRONIZED SCREECH
R. TAGHAVI University of Kansas, Lawrence, KS, US and G. RAMAN NYMA, Inc., Brook Park, OH, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 12 December 1994 p. 2477-2480 Research sponsored by NASA Lewis
(HTN-95-42592) Copyright

The objective of the present work is to study the mixing characteristics of a linear array of supersonic rectangular jets under conditions of screech synchronization. The screech synchronization at a fully expanded jet Mach number of 1.61 is achieved by a precise adjustment of the internozzle spacing. To our knowledge, such an experiment on the resonant mixing of screech synchronized multiple rectangular jets has not been reported before. The results are compared with the case where the screech was suppressed in the multijet configuration. Author (Herner)

A95-87227* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PRECONDITIONED DOMAIN DECOMPOSITION SCHEME FOR THREE-DIMENSIONAL AERODYNAMIC SENSITIVITY ANALYSIS
MOHAMED E. ELESHAKY Old Dominion University, Norfolk, VA, US and OKTAY BAYSAL Old Dominion University, Norfolk, VA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 12 December 1994 p. 2489-2491
(Contract(s)/Grant(s): NAG1-1188)
(HTN-95-42597) Copyright

A discrete sensitivity analysis algorithm had previously been developed and applied to two-dimensional aerodynamic optimization problems, where the computational domains were discretized by using single grids. The sparse, unsymmetric systems of linear equations resulting from this algorithm were solved by a direct matrix inversion matrix. However, for large two-dimensional problems and, practically, all three-dimensional problems, direct inversion methods become inapplicable, primarily due to the prohibitive computer storage needed. In an attempt to alleviate such hindrances, the sensitivity analysis with domain decomposition (SADD) scheme was developed. This scheme divides the computational domain into smaller and nonoverlapping subdomains (multiblock grids) that are solved separately. Then, the final solution is constructed from the subdomain solutions. As the number of grid points in the interface boundaries of the subdomains becomes large, the computer memory required to store the effective coefficient matrix of these interface points starts to increase. Presented in this Technical Note is a preconditioned iterative procedure to overcome this particular problem. Author (Herner)

A95-87365
AERODYNAMIC CHARACTERISTICS OF TRUNCATED AIRFOILS AT HIGH ANGLE OF ATTACK
WILLIAM H. WENTZ, JR. Wichita State University, KS, US (ISSN 0148-7191) 1993 8 p. SAE General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, Kansas, May 18-20, 1993 (SAE PAPER 931227; HTN-95-92545) Copyright

Thick airfoils are commonly used for wind turbine and propeller blade inboard sections, and for struts on aircraft. These airfoils are sometimes truncated for manufacturing convenience, or to save weight. The purpose of this investigation was to study the effects of systematic truncation on airfoil performance. In order to investigate these effects two basic airfoil shapes representative of wind turbine designs were tested: the NACA 23024 and the NACA 64(sub 3)-621. The trailing edges of the models were truncated in steps up to the maximum thickness point. Aerodynamic forces and pitching moments were measured for angles of attack from -10 deg to 90 deg for each truncated model. Wind tunnel tests were conducted in the Witchita State University 2.13m x 3.05m Walter Beech Memorial Wind Tunnel, using constant chord reflection plane models. Tests were conducted at a nominal dynamic pressure of 718 Pa (15 psf), which corresponds to a Mach number of 0.10 and a Reynolds number of 0.65 x 10(exp 6) based on the full airfoil chord.
Author (revised by Herner)

A95-87385
ESTIMATION OF AERODYNAMIC DERIVATIVES: EULER SCHEME VALIDATION AND APPROXIMATE METHODS FOR HYPERSONIC CONFIGURATIONS
T. EGGERS DLR Institute for Design Aerodynamics, Germany, U. HERRMANN DLR Institute for Design Aerodynamics, Germany, and J. SCHONE DLR Institute for Design Aerodynamics, Germany *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 191-200
Copyright

The first part of this paper discusses steps of an Euler code validation for hypersonic configurations. Here, the effect of grid density is investigated and calculated total forces and moments are compared with experimental data for several supersonic onflow conditions, including sideslip and rudder deflection. For sufficiently fine grids a grid converged solution is obtained. Calculated coefficients lie within the uncertainty range of experiment. In the second part, an evaluation of selected approximate methods is given. A comparison of results obtained with approximate methods and the Euler code show large discrepancies especially on the leeward side. In order to include expansion effects in the nose region of blunt bodies, a combined Newtonian/Prandtl-Meyer method is discussed.
Author (Herner)

A95-87395
AERODYNAMICS OF DELTA WINGS WITH APPLICATION TO HIGH- ALPHA FLIGHT MECHANICS
B. W. MCCORMICK Penn State University, University Park, PA, US *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 311-323
Copyright

The steady and unsteady characteristics of delta wings at angles of attack up to approximately 50 degrees are examined. A semi-empirical theory is developed which predicts the steady and unsteady behavior of these wings. These predictions depend significantly upon the bursting of the leading-edge vortices. It is shown, for the steady case, that data for burst point locations collapse to a single curve as a function of the resultant angle between the leading edge and the velocity vector. Author (Herner)

A95-87399
REAL TIME FOR THE CALCULATION OF THE AERODYNAMIC OF AIRCRAFTS WITH DELTA WINGS
K. MOHLENKAMP Technical University of Braunschweig, Braunschweig, Germany and E. FEGEL Technical University of Braunschweig, Braunschweig, Germany *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 357-368
Copyright

For a realistic investigation of the wind aircraft interaction, different engineering models are needed; one for aerodynamics and one for the three-dimensional wind field. In this paper a downburst and a turbulence model will be presented as an example for usable wind fields. Up to now, complex three-dimensional realistic wind models can not be calculated in real time with existing computers. Therefore a matrix wind field was developed. With the help of this we can store the wind speed vectors of a defined area on a hard disk. At last a five-point model of the STS Space Shuttle will be introduced. This model can recognize the wind distribution at several points of the aircraft. The different response of the five-point and the mass-point model to spacial wind fields are shown. Author (Herner)

A95-87400
LOW-SPEED AERODYNAMIC CHARACTERISTICS OF A SLENDER WING WITH VERTICAL FINS
A. BRUEMMER Technical University of Braunschweig, Braunschweig, Germany and D. HUMMEL Technical University of Braunschweig, Braunschweig, Germany *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 369-378
Copyright

At the Institute for Fluid Mechanics of the Technical University of Braunschweig experimental investigations on wing-fin interference were carried out on a basic configuration which consisted of a sharp-edged cropped delta wing (aspect ratio A = 0.93, taper ratio lambda = 0.33) as the vortex generator and half-wing-shaped vertical fins of different size. These fins were located at various spanwise positions: Single fins in the symmetry plane of the configuration as well as double fins at mid halfspan and at the tip of the wing were investigated. Six-component balance measurements and flowfield studies by means of the laser lightsheet method were performed in the Institute's 1.3 m low-speed windtunnel. The results of the comprehensive six-component measurements show the effects of the various fins on the lateral stability of the configuration. The results show that a central fin is less effective than double fins of the same area at the wing tips. Concerning unsymmetrical flight conditions, a configuration with twin fins at mid halfspan position shows lateral stability. For a central fin configuration, sudden and considerable changes of the aerodynamic coefficients occur for certain combinations of the angle of attack and the angle of sideslip. An overview of the flow status for the various fin configurations is given on the basis of flow visualizations. Author (Herner)

A95-87412
EXPERIMENTAL INVESTIGATION OF HYPERSONIC FLOW OVER A WING-BODY COMBINATION
AMARJIT SINGH Cranfield University, Cranfield, Bedford, UK and J. L. STOLLERY Cranfield University, Cranfield, Bedford, UK 1995 10 p. AIAA, International Aerospace Planes and Hypersonics

Technologies Conference, 6th, Chattanooga, TN, April 3-7, 1995
(AIAA PAPER 95-6083; HTN-95-92596) Copyright

An experimental investigation of the hypersonic flow over the lower surface of a wing-body combination has been conducted using the College of Aeronautics gun tunnel. The tests were performed at M(sub infinity) = 8.2 and Re(sub infinity) = 93500/cm at model incidences, alpha = 0, 5 and 10 deg for flap deflection angles, beta = 0, 5, 15, and 25 deg. The schlieren pictures showing top and side views of the model indicate that the body nose shock does not intersect the wing throughout the range of alpha under investigation. Detailed pressure measurements on the lower surface of the wing and flap along with the liquid crystal pictures suggest that the body nose shock does not strike the flap surfaces either. The wing leading edge shock is attached at alpha = 0 and 5 deg but detaches at alpha = 10 deg as shown by plan view schlieren pictures. The liquid crystal pictures and surface pressure measurements indicated attached flow on the lower surface of the wing and flap for beta = 0 and 5 deg at all values of alpha under test. However, at alpha = 0 deg, as the flap angle is increased to 15 deg the flow separates ahead of the hinge line. As incidence is increased the boundary layer becomes transitional giving rise to complex separation patterns around the flap hinge line. The spherically blunted body nose causes strong entropy layer effects over the wing and the trailing edge flap. The surface pressure over the wing and the plateau pressure for separated flow was found to increase from the root to the tip. This is partly because of the decrease in local Reynolds number along the span, however in the present case, entropy layer effects are also likely to affect separation. The entropy layer effects were found to reduce the peak pressures obtainable on the flap. The peak pressures, over the portion of the flap unaffected by entropy layer effects, could be estimated assuming quasi two dimensional flow. Author (Hemer)

A95-87415
NONLINEAR ASYMPTOTIC THEORY OF HYPERSONIC FLOW PAST A CIRCULAR CONE
CHAO-KANG FENG Tamkang University, Tamusi, Taipei, Taiwan, SHEAM-CHYUN LIN National Taiwan Institute of Technology, Taipei, Taiwan, and YUNG-TAI CHOU National Taiwan Institute of Technology, Taipei, Taiwan 1995 9 p. AIAA, International Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, April 3-7, 1995
(HTN-95-92599) Copyright

The essential point of view in this paper is to reexamine the hypersonic small-disturbance theory. A systematic and rigorous approach for obtaining the nonlinear asymptotic equation for hypersonic flow past a circular cone from the Taylor-Maccoll equation is exhibited by considering a general asymptotic expansion of the unified supersonic-hypersonic similarity parameter together with the stretched coordinate. The successive approximate solutions of the nonlinear hypersonic small-disturbance equation were solved by iteration. Both of these approximations provide a closed-form solution, which is convenient to apply in more complicated flow problems. Comparisons of the zeroth-order and first-order approximations for shock location and pressure coefficient on cone surface are given, respectively. The first-order approximation including the nonlinear effects demonstrates better agreement with the exact solution. It is worth noting that this approach offers a deep-insight understanding for the fundamental feature of hypersonic small-disturbance theory. Author (Hemer)

A95-87572
FLOW ALTERATION AND DRAG REDUCTION BY RIBLETS IN A TURBULENT BOUNDARY LAYER
SEONG-RYONG PARK Univ. of Maryland, College Park, MD, US and JAMES M. WALLACE Univ. of Maryland, College Park, MD, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 1 January 1994 p. 31-38
(Contract(s)/Grant(s): NSF-89-1189)
(HTN-95-61199) Copyright

Detailed measurements with a miniature single-sensor hot-wire probe of the streamwise velocity field within a riblet groove of dimensionless size h(expt) approximately equals 14 and s(expt) approximated equals (based on the riblet surface average friction velocity) have been made. The wall shear stress, when integrated over the riblet surface, yields about 4% drag reduction compared with a smooth surface with the same projected area. This is largely due to the greatly diminished wall shear stress near the bottom of the riblet valley. Four-sensor hot-wire probe measurements reveal that riblets significantly reduce the vertical flux of streamline momentum within the riblet valley. Author (Hemer)

A95-87676
TWO-DIMENSIONAL UNSTEADY LEADING-EDGE SEPARATION ON A PITCHING AIRFOIL
P. G. CHOUDHURI Rutgers Univ., Piscataway, NJ, US, D. D. KNIGHT Rutgers Univ., Piscataway, NJ, US, and M. R. VISBAL Wright Lab., Wright-Patt. AFB, OH, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 673-681
(Contract(s)/Grant(s): DAAL-03-91-G-0096)
(HTN-95-81628) Copyright

The initial stages of two-dimensional unsteady leading-edge boundary-layer separation of laminar subsonic flow over a pitching NACA-0012 airfoil have been studied numerically at Reynolds number (based on airfoil chord length) R(sub e) = 10(exp 4), Mach number M(sub infinity) = 0.2, and nondimensional pitch rate are omega(sub 0 sup +) = 0.2. Computations have been performed using two separate algorithms for the compressible laminar Navier-Stokes equations. The first method, denoted the structure grid algorithm, utilizes a structured, boundary fitted C grid and employs the implicit approximate-factorization algorithm of Beam and Warming. The second method, denoted the unstructured grid algorithm, utilizes an unstructured grid of trinagles and employs the flux-difference splitting, method of Roe and a discrete representation of Gauss' theorem for the inviscid and viscous terms, respectively. Both algorithms are second-order accurate in space and time and have been extensively validated through comparison with analytical and previous numerical results for a variety of problems. The results show the emergence of a primary clockwise-rotating recirculating region near the leading edge which can be traced to a pair of critical points (a center and a saddle) that appear within the flowfield, followed by a secondary counter clockwise-rotating recirculating region and a tertiary clockwise-rotating recirculating region. The primary and secondary recirculating regions interact with each other to give rise to the unsteady separation of the boundary layer. Author (Hemer)

A95-87679
EFFECTS OF PERIODIC SPANWISE BLOWING ON DELTA-WING CONFIGURATION CHARACTERISTICS
J. MEYER Israel Institute of Technology, Haifa, Israel and A. SEGINER Israel Institute of Technology, Haifa, Israel AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 708-715
(HTN-95-81631) Copyright

Periodic leading-edge spanwise blowing was tested on a 60-deg swept delta-wing fighter aircraft model in a low-speed wind tunnel, up to an angle-of attack of alpha = 60 deg. At low frequencies, lift and drag coefficients correspsond to the pulsating blowing pressure: when the valve is open, they reach the same values as with continuous blowing, and when it is closed, they agree with the no-blowing values. A lag in the response time is observed, which is equal at low incidences to the freestream convective time, but increases to 30 convective times at alpha = 30-40 deg. Author (Hemer)

A95-87680
NUMERICAL MODEL FOR CIRCULATION-CONTROL FLOWS
R. G. HOLZ McDonnell Douglas Helicopter Co., Mesa, AZ, US, A. A. HASSAN McDonnell Douglas Helicopter Co., Mesa, AZ, US, and HELEN L. REED Arizona State Univ., Tempe, AZ, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 701-707
(HTN-95-81632) Copyright

Current computational models for circulation-control flows have been applied, in most cases, to elliptical airfoils having only one blowing slot. This work describes a two-dimensional Navier-Stokes solver that has been developed for modeling the flowfields of a circular airfoil with two jets. In its original form, the Baldwin-Lomax algebraic turbulence model is shown to be inadequate for describing compund boundary layers such as those produced by the wall jet. A new turbulence model is therefore proposed. To account for the nonequilibrium production of turbulence as the slot exits and for its suppression due to wall curvature, two corrections to the turbulence model were implemented. Author (Herner)

A95-87681

DYNAMIC PITCH-UP OF A DELTA WING

O. K. REDINIOTIS Virginia Polytechnic Institute and State Univ., Blacksburg, VA, US, S. M. KLUTE Virginia Polytechnic Institute and State Univ., Blacksburg, VA, US, N. T. HOANG Virginia Polytechnic Institute and State Univ., Blacksburg, VA, US, and D. P. TELIONIS Virginia Polytechnic Institute and State Univ., Blacksburg, VA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 716-725

(Contract(s)/Grant(s): AFOSR-91-0310)

(HTN-95-81633) Copyright

The trasient flow field over a delta wing during pitch-up motions to very large angles of attack was investigated. Emphasis was directed at the growth and the eventual breakdown of the leading-edge vortices. Delta wind models were tested in a wind tunnel at Reynolds number of order 10(exp 5). The flow field along the trailing edge was mapped out via a seven-hole probe designed, constructed and calibrated to generate time-resolved information. Instantaneous surface pressure measurements were also obtained. Earlier qualitative evidence of hysteresis in the development of the flow was confirmed. Moreover, the present data indicate significant differences of vorticity content between the steady and unsteady motions, for reduced frequencies as low as 0.01. Author (Herner)

A95-87693

DOPPLER LIDAR INVESTIGATION OF WAKE VORTEX TRANSPORT BETWEEN CLOSELY SPACED PARALLEL RUNWAYS

F. KOPP DLR, Oberpfaffenhofen, Germany AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 805-810 Research sponsored by FAG and DLH

(HTN-95-81645) Copyright

The paper demonstrates the potential of the Doppler lidar technique for the investigation of aircraft wake vortices. During several extended field experiments at the Frankfurt/Main Airport, the DLR Laser Dopler anemometer has measured the vortex properties of a large variety of landing aircraft. These data are used to increase the understanding of the behavior of wake vortices with special emphasis on the horizontal vortex transport in ground effect. In particular, the results of the vortex transport considerations are the basis for air traffic control to enhance the efficiency of closely spaced parallel runway systems with respect to wake vortices.

Author (Herner)

A95-88892* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

SYMPOSIUM ON AERODYNAMICS & AEROACOUSTICS, TUCSON, AZ, MAR. 1-2, 1993

K.-Y. FUNG, editor University of Miami, US Singapore World Scientific Pub. Co. Pte. Ltd. (Advanced Series on Fluid Mechanics) 1994 373 p.

(Contract(s)/Grant(s): NAG2-847; NAG3-1436; NAG1-1135)

(ISBN 981-02-1732-3; HTN-95-20853) Copyright

A symposium was held on four areas of aeronautical sciences: wing design, unsteady aerodynamics and separation, aeroacoustics, and self-correcting wind tunnels. For individual titles, see A95-88893 through A95-88903. Herner

A95-88896* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

UNSTEADY AERODYNAMICS OF VORTICAL FLOWS: EARLY AND RECENT DEVELOPMENTS

H. M. ATASSI University of Notre Dame, US *In* Symposium on Aerodynamics & Aeroacoustics, Tucson, AZ, March 1-2, 1993. A95-88892 Singapore World Scientific Pub. Co. Pte. Ltd. (Advanced Series on Fluid Mechanics) 1994 p.121-171

Copyright

The development of aerodynamic theories of streaming motions around bodies with unsteady vortical and entropic disturbances is reviewed. The basic concepts associated with such motions, their interaction with solid boundaries and their noise generating mechanisms are described. The theory was first developed in the approximation wherein the unsteady flow is linearized about a uniform mean flow. This approach has been extensively developed and used in aeroelastic and aeroacoustic calculations. The theory was recently extended to account for the effect of distortion of the incident disturbances by the nonuniform mean flow around the body. This effect is found to have a significant influence on the unsteady aerodynamic force along the body surface and the sound radiated in the far field. Finally, the nonlinear characteristics of unsteady transonic flows are reviewed and recent results of linear and nonlinear computations are presented. Author (Herner)

A95-88898

DETERMINING UNSTEADY 2D AND 3D BOUNDARY LAYER SEPARATION

LEON L. VAN DOMMELEN Florida State University, US and SZU-CHUAN WANG *In* Symposium on Aerodynamics & Aeroacoustics, Tucson, AZ, March 1-2, 1993. A95-88892 Singapore World Scientific Pub. Co. Pte. Ltd. (Advanced Series on Fluid Mechanics) 1994 p. 187-207

(Contract(s)/Grant(s): F49629-89-C-0014)

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This paper explains the differences between steady and unsteady separation processes. It proposes several techniques to diagnose unsteady separation, from the quasi-steady case to fully unsteady. Procedures range from simple applications of the Moore, Rott, and Sears (MRS) conditions to complete Lagrangian solutions of the 3D Lagrangian boundary layer equations. They should be of interest for experimental, computational, and theoretical fluid dynamicists. Author (Herner)

A95-88900

RESPONSE OF A THIN AIRFOIL ENCOUNTERING A STRONG DENSITY DISCONTINUITY

FRANK E. MARBLE Cal Tech, US *In* Symposium on Aerodynamics & Aeroacoustics, Tucson, AZ, March 1-2, 1993. A95-88892 Singapore World Scientific Pub. Co. Pte. Ltd. (Advanced Series on Fluid Mechanics) 1994 p. 231-255

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Airfoil theory for unsteady motion has been developed extensively, assuming the undisturbed medium to be of uniform density, a restriction accurate for motion in the atmosphere. In some instances, notably the airfoils comprising fan, compressor and turbine blade rows, the undisturbed medium may carry density variations or spots, resulting from non-uniformities in temperature or composition, of a size comparable to the blade chord. This condition exists for turbine blades immediately downstream of the main burner of a gas turbine engine where the density fluctuations of the order of 50% may occur. Disturbances of a somewhat smaller magnitude arise from the ingestion of hot boundary layers into fans and exhaust into hovercraft. Because these regions of non-uniform density convect with the moving medium, the airfoil experiences a time varying load and moment which we propose to calculate.The case that will be examined in this paper is the response of a plane lifting airfoil to the passage of a strong density discontinuity normal to the direction of uniform motion of the main stream. The vorticity is then concentrated on the density discontinuity, generated at a rate proportional to the pressure gradient, normal to the flow direction, produced by the field of the airfoil. The problem will be formulated through representing the lifting plane airfoil as a sheet of vortex elements whose distribution is determined to satisfy the boundary conditions on the airfoil in the presence of (1) the vorticity shed from the trailing edge of the airfoil and (2) the vorticity generated in the free stream by non-uniform density. Thus it will use techniques familiar from conventional formulation of thin airfoil theory but, because of the non-uniform density field, will require the introduction of some innovative features. Author (revised by Herner)

A95-88960
AN OVERVIEW OF STATIC AND DYNAMIC AIRFOIL PERFORMANCE
KASIM BIBER Wichita State University, US (ISSN 0148-7191) 1993 14 p. SAE General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, KS, May 18-20, 1993
(SAE PAPER 931228; HTN-95-20921) Copyright

An overview was constructed from available data for static and dynamic stall characteristics of airfoils operating at low speeds. Ephasis was given to the history of changes in the boundary layer development. Separation and stall types were revisited to understand the physics involved with stall hysteresis. Fixed and variable speed, and dynamic stall hysteresis were studied. The study reveals the need to extend the parametric studies of single airfoils to multi-element airfoils. This is evident from wind tunnel tests of a flapped airfoil. Flap deployment brings the low Reynolds number hysteresis phenomenon back to the airfoil operating at relatively high test Reynolds number. Author (Herner)

A95-88965
DISTURBANCE GENERATION IN SUPERSONIC JETS UNDER ACOUSTIC EXCITATION
V. G. PIMSHTEIN Central Aerohydrodynamic Institute, Moscow, Russia AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1345-1349
(HTN-95-20926) Copyright

Experimental results are presented on the interaction of saw-toothed high-intensity sound waves (sound pressure level (SPL) = 160-170 dB) with an axisymmetric supersonic air jet. The flow and sound waves were visualized by the direct shadowgraph method using a spark light source with exposure time of 2 X 10(exp -7)s. It is shown that disturbance increase increment in a supersonic jet under external acoustic excitation depends on the angle of incidence of the sound wave to the jet boundary. The most intensive increase in jet disturbances occurs at an oblique sound incidence when the sound phase velocity along the boundary approaches the disturbance propagation velocity. For sufficiently intense jet disturbances, a shock wave formation induced by and moving with these disturbances may arise. Sound interaction with a supersonic jet takes place within a small flow zone near the nozzle exit; disturbances already developed are not noticeably affected by the sound intensity of 170 dB reached in the experiment. Author (Herner)

A95-88966
ROTATING KIRCHHOFF METHOD FOR THREE-DIMENSIONAL TRANSONIC BLADE-VORTEX INTERACTION HOVER NOISE
YU XUE University of Minnesota, Minneapolis, MN, US and A. S. LYRINTZIS University of Minnesota, Minneapolis, MN, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1350-1359
(HTN-95-20927) Copyright

Three dimensional transonic blade-vortex interaction (BVI) noise is studied numerically. The unsteady transonic full-potential rotor (FPR) code is used for the simulation of the transonic BVI near-field flow. The rotating Kirchoff method is used for the extension to the acoustic far field. Two rotating Kirchoff formulations are developed for the three-dimensional BVI far-field noise prediction. The first formulation (Morino's method) is for an observer rotating with the blade. This allows the direct comparison with the computational fluid dynamics results. The second formulation (Farassat's method) is for a stationary observer and allows a direct comparison with acoustic experiments. Test results are presented in this paper for a rotating point source and a transonic high-speed impulsive (HSI) noise prediction. The results for a parallel vortex line interacting with a nonlifting hovering rotor are presented and various cases are shown. The understanding of the three-dimensional transonic BVI noise mechanisms and directivity are discussed here.
Author (Herner)

A95-88967* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTING UNSTEADY SHOCK WAVES FOR AEROACOUSTIC APPLICATIONS
MEADOWS, KRISTINE R. NASA Langley Research Center, Hampton, VA, US, DAVID A. CAUGHEY Cornell University, Ithaca, NY, US, and JAY CASPER ViGYAN, Inc., Hampton, VA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1360-1366
(HTN-95-20928) Copyright

The computation of unsteady shock waves, which contribute significantly to noise generation in supersonic jet flows, is investigated. This paper focuses on the difficulties of computing slowly moving shock waves. Numerical error is found to manifest itself principally as a spurious entropy wave. Calculations presented are performed using a third order essentially nonoscillatory scheme. The effect of stencil biasing parameters and of two versions of numerical flux formulas on the magnitude of spurious entropy are investigated. The level of numerical error introduced in the calculation in quantified as a function of shock pressure ratio, shock speed, Courant number, and mesh density. The spurious entropy relative to the entropy jump across a static shock decreases with increasing shock strength and shock velocity relative to the grid, but is insensitive to Courant number. The structure of the spurious entropy wave is affected by the choice of flux formulas and algorithm biasing parameters. The effect of the spurious numerical waves on the calculation of sound amplification by a shock wave is investigated. For this class of problem, the acoustic pressure waves are relatively unaffected by the spurious numerical phenomena. Author (Herner)

A95-88968* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONTROL-NONLINEAR-NONSTATIONARY STRUCTURAL RESPONSE AND RADIATION NEAR A SUPERSONIC JET
LUCIO MAESTRELLO NASA Langley Research Center, Hampton, VA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1367-1376
(HTN-95-20929) Copyright

This paper is on the control of nonlinear-nonstationary vibration of a frame-stringer structure resulting from high levels of excitaation from a nearby supersonic jet exhaust. The structure exhibits periodic, chaotic, or random behaviors when forced by high-intensity sound from a supersonic jet exhaust with shock loading superimposed on the broadband response. The time history of the pressure, showing the rotation and flapping of the shock structure in the jet column due to large-scale instabilities, indicates that the response is not only nonlinear but also nonstationary. The acoustic pressure radiated by the structure also contains shocks and the formation of harmonics with distance. Control of the structural response is achieved by actively forcing the structure with an actuator at the shock oscillation frequency whose amplitude is locked into a self-control cycle. Results show that the peak power level is reduced by a factor of 63, or 18 dB. As a result, new broadband components emerge with at least four harmonics. At accelerating and decelerating supersonic speeds, the exhaust from the jet induces higher transient loading on the nearby flexible structure due to the occurence of multiple shocks from the jet. Author (Herner)

A95-88969* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SUPERSONIC AND HYPERSONIC SHOCK/BOUNDARY-LAYER INTERACTION DATABASE
GARY S. SETTLES Pennsylvania State University, University Park, PA, US and LORI J. DODSON Pennsylvania State University, University Park, PA, US AIAA Journal (ISSN 0001-1452) vol. 32,

no. 7 July 1994 p. 1377-1383
(Contract(s)/Grant(s): NAG2-565)
(HTN-95-20930) Copyright

An assessment is given of existing shock wave/tubulent boundary-layer interaction experiments having sufficient quality to guide turbulence modeling and code validation efforts. Although the focus of this work is hypersonic, experiments at Mach numbers as low as 3 were considered. The principal means of identifying candidate studies was a computerized search of the AIAA Aerospace Database. Several hundred candidate studies were examined and over 100 of these were subjected to a rigorous set of acceptance criteria for inclusion in the data-base. Nineteen experiments were found to meet these criteria, of which only seven were in the hypersonic regime (M is greater than 5). Author (Herner)

A95-88970
LINEAR DISTURBANCES IN HYPERSONIC, CHEMICALLY REACTING SHOCK LAYERS
GREG STUCKERT Arizona State University, Tempe, AZ, US and HELEN L. REED Arizona State University, Tempe, AZ, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1384-1393
(HTN-95-20931) Copyright

The effects of equilibrium- and nonequilibrium-air chemical reactions on the linear stability of a Mach 25, 10-deg half-angle sharp-cone shock layer are investigated. First, the basic state is computed using the parabolized Navier-Stokes equations with a shock-fitting scheme. This eliminates spurious numerical oscillations that could adversely affect the stability analysis. Spatial stability analyses are then described for three different approximations of the physics: perfect gas, air in local chemical equilibrium, and air in chemical noneqilibrium. It is shown in both the equilibrium- and nonequilibrium-air calculations that the second mode of Mack is shifted to lower frequencies. This is attributed to the increase in the size of the region of relative supersonic flow due to the lower speeds of sound in the relatively cooler boundary layers. Finally, in the equilibrium air calculations, modes that travel supersonically relative to the inviscid region of the shock layer are shown to exist. These modes are a super-position of incoming and outgoing disturbances whose magnitude oscillates with the distance normal to the wall in the inviscid region of the shock layer. This oscillatory behavior is possible only because the shock standoff distance is finite.
Author (Herner)

A95-88971
BEHAVIOR OF THE JOHNSON-KING TURBULENCE MODEL IN AXISYMMETRIC SUPERSONIC FLOWS
YAAUO NOGUCHI University of Salford, Salford, UK and TOSHIMASA SHIRATORI Tokyo Metropolitan Institute of Technology, Tokyo, Japan AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1394-1398
(HTN-95-20932) Copyright

A series of systematic tests are carried out on the Johnson-King turbulence model (JKM) for applied compressible aerodynamics. Two-dimensional flows with a moderate adverse pressure gradient and without separation at various Mach numbers are used for the tests. The results are compared with the Baldwin-Lomax model (BLM) as well as the measurements. The agreement of the results of both models and the measured data becomes poorer at higher Mach numbers. Overall, the performance of the JKM is slightly better than BLM except with respect to the prediction of the skin friction coefficient. The ordinary differential equation (ODE) in the JMK is effective in improving the prediction. However, the effects of the ODE are not as significant as in flows with separation. Use of the JKM even in nonseparated flows may improve accuracy of prediction, which has not been clearly established before this work.
Author (Herner)

A95-88974
MODELING THREE-DIMENSIONAL GAS-TURBINE COMBUSTOR MODEL FLOW USING SECOND-MOMENT CLOSURE
C. A. LIN National Tsing Hua University, Hsinchu, Taiwan and C. M. LU National Tsing Hua University, Hsinchu, Taiwan AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1416-1422
(Contract(s)/Grant(s): NSC-81-0401-E-007-537)
(HTN-95-20935) Copyright

Numerical predictions were applied to a gas-tubine combustor model flow where dilutions jets were injected radially inwards into a swirling flow, leading to a very strong interaction between the two streams. Effects of differeent inlet swirl level to the interior flowfield were investigated numerically, and the predicted mean and turbulence results were also contrasted with measurements. The present study demonstrates that the characteristics of the combustor flow are closely linked to the representation of the interaction between the swirl field and the jets. Diffusive transport was found to be highly influential, and this also increases the importance of turbulence representation. Comparisons with experimental measurements indicated that the stress model with an anisotropy modified epsilon source combined with quadradic approximation of convection fluxes represents the flowfield reasonably well, in contrast to the kappa-epsilon model whose diffusive nature leads to an intense vortex core near the centerline region. Reduction of strength of the centerline recirculation zone due to the elevated level of swirl momentum transport from the swirler was also well reproduced by the stress model variant. Author (Herner)

A95-88976
VORTEX CUTTING BY A BLADE, PART 2: COMPUTATIONS OF VORTEX RESPONSE
J. S. MARSHALL University of Iowa, Iowa City, IA, US and R. YALAMANCHILI Florida Atlantic University, Boca Raton, FL, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 11428-1436
(Contract(s)/Grant(s): DAAL03-92-G-0277)
(HTN-95-20937) Copyright

Computations of the interaction between a line vortex and blades of various thicknesses and angles of attack traveling in a direction normal to the vortex axis have been performed. A procedure to enable instantaneous cutting of the vortex is used in the case of thin blades to study vortex interaction with the blade both before and after vortex cutting has occured. To isolate the effect of blade thickness on vortex bending, additional computations have been performed of the interaction between a line vortex and circular cylinders of various diameters. The vortex is represented by a filament model which includes axial flow within the core and nonuniform core area, and the effect of the blade or cylinder on the vortex and the subsequent variation in vortex core radius. It is found that the amount of vortex bending is primarily dependent on the ratio of blade thickness T (or diameter D of a circular cylinder) to ambient vortex core radius sigma(sub 0). For blades with T/sigma (sub 0) of order unity or less, very little bending is observed for attack angles under the stall limit. For cases in which significant vortex bending is observed (T/sigma(sub 0) or D/sigma(sub 0) greater than order unity), increase in blade or cylinder forward speed results in a decrease in vortex core radius for a given amount of bending of the vortex axis. Vortex shocks and expansion waves are also observed to propagate on the vortex after cutting by a blade, as predicted in Part 1 of the study. Author (Herner)

A95-88977
ELLIPTIC TIP EFFECTS ON THE VORTEX WAKE OF AN AXISYMMETRIC BODY AT INCIDENCE
DAVID H. BRIDGES Mississippi State University, Mississippi State, MS, US and HANS G. HORNUNG Calfomia Institute of Technology, Pasadena, CA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1437-1445
(Contract(s)/Grant(s): N00014-90-J-1305)
(HTN-95-20938) Copyright

The effectiveness of a new version of an elliptic cross-section tip in controlling the asymmetry of the vortex wake of an axisymmetric body at angle of attack has been studied. The elliptic cross sections were generated using two sixth-degree polynomials such that the tip radius, slope and curvature would match those of a right circular cone at the point where the polynomial became tangent to a cone generator. The tip was found to be effective in varying the vortex wake geometry of a right circular cone at large angle of attack. The measured side force coefficient varied smoothly with tip roll angle for the two lowest angles of attack studied and exhibited square-wave and more undesirable variations for the larger angles of attack studied. These square-wave and peak, reduction-in-magnitude, and change-in-sign variations were caused by vortex breakaway, which allowed vortex crossover to occur. Ahead of vortex breakaway, the elliptic cross-section tip yielded smooth variations of vortex wake asymmetry with tip roll angle, indicating that the tip would possibly be a feasible control device for high-performance fighter aircraft at high angle of attack. Author (Herner)

A95-88980* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

DESIGN AND OPERATION OF A SUPERSONIC ANNULAR FLOW FACILITY

K. E. WILLIAMS University of Washington, Seattle, WA, US, F. B. GESSNER University of Washington, Seattle, WA, US, and G. J. HARLOFF Sverdrup Technology, Inc., Brook Park, OH, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1528-1531
(Contract(s)/Grant(s): NAG3-376; NAS3-25266)
(HTN-95-20941) Copyright

Supersonic annular flow passages exist in propulsion applications that include dual combustion ramjet engines where a supersonic annular flow (the outer flow) mixes with a sonic (or supersonic) gas generator flow (the inner flow) in the shock expansion zone downstream of the gas generator nozzle exit. Other engine designs include components in the form of annular ducts whose cross-sectional area varies in the streamwise flow direction. In some of these configurations, it is necessary to support the outer shroud (cowl) by means of struts positioned between the cowl and centerbody. To investigate the distorting influence of these struts on the local flow structure, it is first necessary to ensure that the intrinsic flow without struts is free of wave reflections and the effects of upstream disturbances. It is also necessary to demonstrate that the intrinsic flow exhibits the characteristics of a well-defined turbulent boundary layer flow, so that changes in the local flow structure induced by the presence of struts can be interpreted properly. The purpose of this Note is to demonstrate that a supersonic flow facility that meets these objectives has been developed. Author (Herner)

A95-88987

ADAPTIVE COMPUTATIONS OF FLOW AROUND A DELTA WING WITH VORTEX BREAKDOWN

DAVID L. MODIANO Massachusetts Institute of Technology, Cambridge, MA, US and EARLL M. MURMAN Massachusetts Institute of Technology, Cambridge, MA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1545-1547
(Contract(s)/Grant(s): AF-AFOSR-89-0395A)
(HTN-95-20948) Copyright

The next generation of fighter aircraft is being designed to fly at a very high angle of attack, at which vortex breakdown occurs. The two typical types of breakdown are the bubble form and the spiral form, which are characterized by the geometry of the flow downstream of the breakdown. This Note presents simulations of vortex breakdown above a stationary delta wing over a range of angles of attack. Adaptive refinement is used to add mesh nodes in the region of the vortex. Numerical simulations of vortex breakdown over a stationary delta wing have been reported by various researchers. No calculations have been reported using adaptive mesh methods.
Author (Herner)

A95-88994

STABILITY OF MAGNETIC BEARING-ROTOR SYSTEMS AND THE EFFECTS OF GRAVITY AND DAMPING

P. ZHONG University of Virginia, Charlottesville, VA, US and M. A. TOWNSEND University of Virginia, Charlottesville, VA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1492-1499
(HTN-95-20955) Copyright

New and general stability criteria are developed for magnetic bearing-rotor systems under pracical conditions of system operation and failure based on the Lyapunov second (direct) method. The unperturbed (fully nonlinear) stability of a conventional magnetic bearing-rotor configuration is analyzed for zero gravity; these results are shown to apply with gravity, based on observed similarities of the nonlinear Lagrangian equations. In addition to known results for stability and instability, the system can be stable when a magnetic bearing fails (has negative stiffness), but the net stiffness is still positive. A complete set of sufficient conditions are derived. This temporary stability depends upon inherent gyroscopic forces and is lost when dissipative forces are introduced. However, even with damping the gyroscopic forces improve the system's relative stability. The results are applicable to other gyroscopic systems.
Author (Herner)

A95-88998* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

DEMONSTRATION OF AN ELASTICALLY COUPLED TWIST CONTROL CONCEPT FOR TILT ROTOR BLADE APPLICATION

R. C. LAKE NASA Langley Research Center, Hampton, VA, US, M. W. NIXON NASA Langley Research Center, Hampton, VA, US, M. L. WILBUR NASA Langley Research Center, Hampton, VA, US, J. D. SINGLETON NASA Langley Research Center, Hampton, VA, US, and P. H. MIRICK NASA Langley Research Center, Hampton, VA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1549-1551
(HTN-95-20959) Copyright

The purpose of this Note is to present results from an analytic/experimental study that investigated the potential for passively changing blade twist through the use of extension-twist coupling. A set of composite model rotor blades was manufactured from existing blade molds for a low-twist metal helicopter rotor blade, with a view toward establishing a preliminary proof concept for extension-twist-coupled rotor blades. Data were obtained in hover for both a ballasted and unballasted blade configuration in sea-level atmospheric conditions. Test data were compared with results obtained from a geometrically nonlinear analysis of a detailed finite element model of the rotor blade developed in MSC/NASTRAN.
Author (revised by Herner)

A95-89185

MODELING AERODYNAMIC PROBLEMS USING SMOOTHED PARTICLE HYDRODYNAMICS (SPH)

DAVID J. AMDAHL Phillips Lab., US (ISSN 0148-7191) 1993 8 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932512; HTN-95-A1465) Copyright

Smoothed Particle Hydrodynamics (SPH) is a numerical method that solves the Lagrangian conservative equations of mass, momentum, and energy without using a computational grid. In the past, SPH has been used to solve problems of astrophysics, hypervelocity collisions, and explosions. This work has extended the application of SPH by solving problems involving inviscid, compressible aerodynamic flow. New boundary conditions were developed, so SPH could solve these types of problems. This paper will provide a short history of SPH, an introduction to the method, discuss the transformation of the governing fluid equations into the SPH formulation, and present several aerodynamic test cases. The power of SPH is that it requires no computational grid. This feature may significantly reduce the time required for the engineer to calculate computational solutions or may simplify the numerical techniques used to solve complex problems, such as moving body problems.
Author (Herner)

A95-89186

COMPUTATIONAL STUDY OF BOUNDARY LAYER CONTROL FOR IMPROVING AIRFOIL PERFORMANCE

CHANG-REN CHEN Missouri Univ., Rolla, MO, US and SHEN C. LEE Missouri Univ., Rolla, MO, US (ISSN 0148-7191) 1993 8 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993

(SAE PAPER 932513; HTN-95-A1466) Copyright

A computational method was developed for investigating boundary layer control. Solutions of the Reynolds-averaged Navier-Stokes equations were obtained using the two-equation k-epsilon turbulence model which includes the low-Reynolds-number effect in the near-wall region. Stream function and vorticity together with the turbulent kinetic energy and its dissipation rate were calculated for the flowfield in a body-fitted coordinate system. By increasing the amount of suction on the upper surface, flow separation could be totally eliminated. Transition from laminar to turbulent flow was delayed. Aerodynamic performance was substantially improved. Author (Herner)

A95-89187

COMPUTATIONAL AERODYNAMIC ANALYSIS ON THE OPEN SKIES AIRCRAFT

MARK S. JURKOVICH United States Air Force, Wright-Patterson AFB, OH, US, JAMES C. SLAVEY United States Air Force, Wright-Patterson AFB, OH, US, and ROBERT W. WEYER United States Air Force, Wright-Patterson AFB, OH, US (ISSN 0148-7191) 1993 9 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993

(SAE PAPER 932514; HTN-95-A1467) Copyright

A series of Computational Fluid Dynamic (CFD) studies have been performed on a WC-135B aircraft that has been modified at Wright-Patterson AFB (WPAFB) for the Open Skies program. The studies included use of a panel method, full potential method, and Navier-Stokes methods in 2-D, axisymmetric, and 3-D. While providing information useful to the Open Skies program, the studies also provide a good example of how lower order and higher order computational aerodynamic methods can be used together to obtain the maximum benefit from CFD. The panel method was used for numerous trade studies to help determine the proper configuration and conditions for the Navier-Stokes studies. Flight test confirmed the 3-D Navier-Stokes results. Author (revised by Herner)

A95-89188

NONLINEAR ANALYSIS OF SWEPT WING TRANSITIONAL BOUNDARY LAYERS

GREGORY K. STUCKERT DynaFlow, Inc., US and THORWALD HERBERT DynaFlow, Inc., US (ISSN 0148-7191) 1993 14 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993

(SAE PAPER 932515; HTN-95-A1468) Copyright

Transition to turbulence induced by unstable stationary cross-flow vortices in a three-dimensional laminar boundary layer on a Mach 1.5, 25 deg swept wing is investigated with the nonlinear compressible Parabolized Stability Equations (PSE). The wing has 3m span, 1m chord, and is untwisted and untapered. Body-fitted coordinates are used to account for all curvature effects of the wing's NACA 64A010 airfoil. Author (revised by Herner)

A95-89191

COMPUTATIONAL STUDY OF A TWO-SLOT CIRCULATION CONTROL AIRFOIL

D. J. FERGUSON Phillips Lab., US, M. E. FRANKE Air Force Inst. of Tech., Wright-Patterson AFB, OH, US, and S. L. WILLIAMS Aeronautical Systems Center, Wright-Patterson AFB, OH, US (ISSN 0148-7191) 1993 6 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993

(SAE PAPER 932531; HTN-95-A1471) Copyright

Predictions of the aerodynamic coefficients for a two-slot circulation control airfoil are made by solving the two-dimensional, compressible, mass-averaged, Navier-Stokes equations. Numerical solutions are obtained by using the Beam-Warming implicit approximate factorization technique and the Baldwin-Lomax turbulence model with a curvature correction. Predictions using different combinations of blowing momentum coefficients with each of the two slots are discussed and compared with previous single-slot numerical results. Author (Herner)

A95-89192

COMPUTATIONAL FLUID DYNAMICS WITH ICING EFFECTS

THOMAS N. MOUCH USAF Academy, CO, US and C. EDWARD LAN Kansas Univ., KS, US (ISSN 0148-7191) 1993 12 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993

(SAE PAPER 932532; HTN-95-A1472) Copyright

A quick, computationally inexpensive technique has been developed for the analysis of a full aircraft configuration with iced surfaces. Viscous effects for the flow field about an airfoil with an iced leading edge are accounted for in a thin-layer Navier-Stokes code (ARC2D). A panel code (PMARC) solves the flow field away from the body. The results of the airfoil analysis represent the near-field solutions and are used to modify the boundary conditions in the three-dimensional calculations with the panel code by matching the local circulation. This process is repeated until the total lift coefficient between successive iterations differs by less than a specified value. Examples showing good comparison between the 3-D calculations and experimental data are provided. Author (Herner)

A95-89199

THE EFFECT OF WING SWEEP BACK UPON TRANSITION IN HYPERSONIC FLOW

D. I. A. POLL University of Manchester, Manchester, UK 3 Apr. 1995 10 p. Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, April 3-17, 1995

(AIAA PAPER 95-6090; HTN-95-B0255) Copyright

Almost all configuration concepts for aerospace planes involve highly swept, relatively thin wings. The main resaon for this is the need for high lift and low drag during the ascent phase and the latter stages of the descent phase. However, the use of thin wings creates a problem with heating loads. This is severe in the region of the leading edge, particularly at low angles of attack. The problem is compounded by the fact that the three-dimensional flows occuring near swept leading edges can undergo transition to turbulence at relatively low Reynolds numbers. These transition mechanisms are not well understood. The objective of the paper is to review current knowledge and assess its relevance to the performance of hypersonic vehicles. Author (revised by Herner)

A95-89200

AERODYNAMIC OFF-DESIGN BEHAVIOR OF INTEGRATED WAVERIDERS FROM TAKE-OFF UP TO HYPERSONIC FLIGHT

T. EGGERS Institute of Design Aerodynamics, Braunschweig, Germany, D. STROHMEYER Institute of Design Aerodynamics, Braunschweig, Germany, H. NICKEL Institute of Design Aerodynamics, Braunschweig, Germany, and R. RADESPIEL Institute of Design Aerodynamics, Braunschweig, Germany 3 Apr. 1995 9 p. Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, April 3-17, 1995

(AIAA PAPER 95-6091; HTN-95-B0256) Copyright

The aerodynamic behavior of a waverider representing the hypersonic lower stage of a two stage to orbit (TSTO) system is discussed. The investigation covers the complete speed range from subsonic high lift up to hypersonic flight close to the design point of the waverider. Several interesting flow phenomena are described which govern the aerodynamic behavior. It is found that the favorable off-design behavior of hypersonic waveriders allows the practical use of waverider vehicles far away from their particular design flow conditions. Therefore, waveriders are excellent designs for acceleration dominated missions such as airbreathing TSTO systems. Author (revised by Herner)

A95-89641

AIR DATA PREDICTION FROM SURFACE PRESSURE MEASUREMENTS ON GUIDED MUNITIONS

M. B. ANDERSON Sverdrup Technology, Inc, Eglin Air Force Base, FL, United States, W. R. LAWRENCE, and J. L. LOPEZ Journal of

Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 18, no. 2 March-April 1995 p. 355-360 refs
(BTN-95-EIX95282706664) Copyright

The control of guided munitions over wide ranges of flight conditions has posed new requirements for estimating air data parameters. A common approach to meet the control stability margins and time response requirements is varying autopilot gains as a function of estimated air data parameters. A feasibility study to estimate air data parameters using flush-orifice pressure sensors has been completed. Wind-tunnel measurements of static pressure on sensors mounted on a representative missile nose were used. The primary objective of this study was to explore options for in-flight estimation of air data parameters using only the static pressure data base. The air data parameters of interest include Mach number, angle of attack, aerodynamic roll angle, and freestream pressure. An iterative process based on the differential corrections method was used to determine the air data parameters and expected error in the final estimates. Examples are given that provide sensitivity to pressure measurement noise and different sensor configurations. The air data estimates obtained with this method are suitable for autopilot gain scheduling over a wide range of flight conditions. Author (EI)

A95-89665
NOTE ON PREDICTION OF AERODYNAMIC LIFT/DRAG RATIO OF WIG (WING-IN-GROUND) AT CRUISE
SHIGENORI ANDO Tokushima Bunri Univ, Kagawa, Japan Transactions of the Japan Society for Aeronautical and Space Sciences (ISSN 0549-3811) vol. 37, no. 118 February 1995 p. 263-277 refs
(BTN-95-EIX95282705925) Copyright

There are a number of methods for predicting aerodynamic performance of WIG (Wing-in-Ground) effect vehicles, which include both theoretical and empirical formulas or charts. But no thoroughgoing survey over them has yet been published. In this paper, all methods are divided into three categories. The first is empirical methods. The second is 'classical' theories. And the third is 'Split Orifice Flow Model.' The basic performance criterion may be lift/drag ratio, while a simpler and easier one is e, which is ratio of effective to geometric aspect ratio A(sub eff)/A. It is found that the latter criterion is not always defined for all prediction methods examined here. It is also found that there are a significant variety of source parameters causing the ground effect, such as B/h, c/h, or the midway square root of (B/h)(c/h). Most methods agree fairly well with one another within the practically important domain, say 2 less than e less than 5 and 10 less than B/h less than 50. But the differences among methods still significantly affect selection of the geometric aspect ratio of main wing of WIG. At the present state, however, the present author cannot select the best one among them. It is an important problem for designing WIG left in future. It is especially noteworthy that Russian empirical chart by Volkov et al. suggests existence of upper limit for L/D of WIG, which is about 31-32. Author (EI)

A95-90060* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ACCURATE DRAG PREDICTION: A PREREQUISITE FOR DRAG REDUCTION RESEARCH
KENT J. WONG California Univ., Davis, CA, US, TRICIA K. AYERS California Univ., Davis, CA, US, and C. P. VAN DAM California Univ., Davis, CA, US (ISSN 0148-7191) 1993 10 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(Contract(s)/Grant(s): NCA2-397; NCA2-581)
(SAE PAPER 932571; HTN-95-A1485) Copyright

An improved technique for drag prediction based on the analysis of wake flows is presented and demonstrated. The technique is demonstrated using three-dimensional flow field solutions obtained with several Euler codes. The flow field solutions are obtained for several wing configurations at both lifting and nonlifting conditions for a range of speeds. At subsonic speeds, the induced-drag prediction is shown to be more accurate (and virtually independent of numerical viscosity levels in the Euler flow field solutions) than the prediction obtained by surface integration. At transonic speeds, a separate wave-drag prediction procedure allows the decomposition of the total inviscid drag into wave drag and induced drag. Preliminary results indicate that the drag-prediction technique in a slightly revised form may be applicable to predict induced drag and wave drag at supersonic speeds. Author (Herner)

A95-90061
LOW REYNOLDS NUMBER LAMINAR SEPARATION BUBBLE CONTROL USING A BACKWARD FACING STEP
JOSE RODRIGUEZ Embry-Riddle Aeronautical Univ., US and DOMINIQUE ROTHAN Embry-Riddle Aeronautical Univ., US (ISSN 0148-7191) 1993 9 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932572; HTN-95-A1486) Copyright

A backward facing step is used to increase the lift to drag ratio of an airfoil with a separation bubble. Three airfoils are tested leading to the conclusion that the step works better for airfoils that have large separation bubbles near the mid-chord. It does not work well for separation bubbles near the leading edge, but has a positive effect for a separation bubble closer to the trailing edge. Results are preliminary and indicate that research is needed to characterize the size and location of the step, as well as the effect of freestream turbulence and Reynolds number. Author (Herner)

A95-90062
ON THE DIFFERENCES BETWEEN THE EFFECT OF ACOUSTIC PERTURBATION AND UNSTEADY BLEED IN CONTROLLING FLOW SEPARATION OVER A CYLINDER
SUMON K. SINHA Mississippi Univ., MS, US and DIPANKAR PAL Mississippi Univ., MS, US (ISSN 0148-7191) 1993 14 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993 Research sponsored by AFOSR
(SAE PAPER 932573; HTN-95-A1487) Copyright

The effect of three different modes of acoustic excitation on an unsteady separating flow over a circular cylinder at a Reynolds number (Re(sub d)) of about 1.5 x 10(exp 5) has been investigated. The acoustic exciters included (1) a speaker mounted inside the cylinder and blowing through a narrow spanwise slot; (2) a circular piezo-electric acoustic transducer mounted flush with the surface; and (3) strip shaped flush mounted acoustic transducers. The first mode of excitation was judged most effective at about 1.3 kHz, based on changes in the time-averaged surface pressure distribution on the cylinder. The corresponding frequencies for (2) and (3) were 7 kHz and 2.25 kHz respectively. The transducers (2) and (3) did not introduce the blowing and suction effects of transducer (1). Transducer (2) increased the mean surface pressure slightly, while (1) and (3) reduced it. Author (Herner)

A95-90063
A BRIEF SURVEY OF WING TIP DEVICES FOR DRAG REDUCTION
KAMRAN ROKHSAZ Wichita State Univ., Wichita, KS, US (ISSN 0148-7191) 1993 10 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932574; HTN-95-A1488) Copyright

A short survey of wing tip geometries for drag reduction is presented. These devices have been divided into two broad categories of passive and active. The first category is made of fixed geometries, while the second group is made of those employing moving parts. The former group is further divided into planar and nonplanar designs. In every case, a brief explanation of the underlying logic is given. Altogether, more than fifteen completely different designs and over seventy references have been cited. Some of these designs, such as winglets, have been explored for many years and have proven to be very effective at reducing the induced drag at higher values of lift coefficient. Some others, such as wing tip turbines, have just begun to attract attention. Wing tip fuel tanks, not being solely employed for drag reduction, have not been included in this paper. Author (Herner)

A95-90268
ROTOR-WAKE-INDUCED FLOW SEPARATION ON A LIFTING SURFACE
S. M. FOLEY Georgia Institute of Technology, Atlanta, GA, US, R. B. FUNK Georgia Institute of Technology, Atlanta, GA, US, P. A. FAWCETT Georgia Institute of Technology, Atlanta, GA, US, and N. M. KOMERATH Georgia Institute of Technology, Atlanta, GA, US
American Helicopter Society, Journal (ISSN 0002-8711) vol. 40, no. 2 April 1995 p. 24-27 Research supported by the U.S. Army Research Office and the NSF
(HTN-95-01082) Copyright
Rotor wake vortex interaction causes flow separation on the upper surface of a lifting surface at low angles of attack, where the time-averaged flow would be expected to remain fully attached. This phenomenon is studied using a full-scale UH-1 stabilator and a two bladed teetering rotor in a wind tunnel. A large once-per- rev pressure fluctuation is observed. Strong time-averaged spanwise flow is observed downstream of the unsteady separation line. The vortex interaction effect decreases with increasing advance ratio. These results are insensitive to small perturbations of the flowfield caused by movement of a small lifting surface upstream. Author (Herner)

A95-90273* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NAVIER-STOKES CALCULATIONS OF ROTOR-AIRFRAME INTERACTION IN FORWARD FLIGHT
LAITH A. J. ZORI Iowa State University, Ames, IA, US and R. GANESH RAJAGOPALAN Iowa State University, Ames, IA, US
American Helicopter Society, Journal (ISSN 0002-8711) vol. 40, no. 2 April 1995 p. 57-67 Research supported by the Iowa State University Computation Center and NASA Ames
(Contract(s)/Grant(s): NAG1-P1267)
(HTN-95-01087) Copyright
A method for analyzing the mutual aerodynamic interaction between a rotor and an airframe model has been developed. This technique models the rotor implicitly through the source terms of the momentum equations. A three-dimensional, incompressible, laminar, Navier-Stokes solver in cylindrical coordinates was developed for analyzing the rotor-airframe problem. The calculations are performed on a simplified rotor-airframe model at an advance ratio of 0.1. The airframe surface pressure predictions are found to be in good agreement with wind tunnel test data. Results are also presented for velocity and pressure field distributions in the wake of the rotor. Author (Herner)

A95-90275
A NOTE ON THE INTERPRETATION OF MINI-TUFT PHOTOGRAPHS
D. G. MABEY Imperial College of Science, London, England, UK, B. L. WELSH DRA, Bedford, UK, and C. R. PYNE DRA, Bedford, UK
Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 985 May 1995 p. 178-182
(HTN-95-01089) Copyright
Although mini-tufts are considered generally to show the surface flow direction on windswept surfaces, there is some uncertainty about their correct interpretation, particularly as three- dimensional flows approach separation. This note provides some guidance on this controversial question, based on experience with mini-tufts on wings, fins and canards in the DRA 13 ft x 9 ft low speed wind-tunnel at Bedford. An illustration of the value of the technique is given. Mini-tuft photographs are used to identify the trailing edge condition which relates to the classification of the steady and fluctuation pressure distributions observed a swept wing with a conical, separated flow. Author (Herner)

A95-90276
MEASUREMENT OF DRAG USING A MOMENTUM BALANCE
L. C. SQUIRE Cambridge University, Cambridge, UK
Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 985 May 1995 p. 183-186
(HTN-95-01090) Copyright
This note presents the results of the application of a momentum control surface analysis to the estimation of the drag of bodies and surfaces placed in the test section of a wind tunnel. The assumptions of the method are stated and accuracy of the method considered with particular reference to the drag of the riblet surfaces at high subsonic speeds, the drag of two-dimensional cavities at both high subsonic and low supersonic speeds, and the drag of manipulators at high subsonic speeds. Author (Herner)

A95-90277
DRAG REDUCTION IN A RECTANGULAR DUCT USING RIBLETS
A. R. MOORE University of Bristol, Bristol, UK and M. V. LOWSON University of Bristol, Bristol, UK
Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 985 May 1995 p. 187-193 Research supported by the Rolls-Royce plc in Derby and the SERC
(HTN-95-01091) Copyright
An experimental investigation has been made into the effects of riblets on the drag in a rectangular duct of aspect ratio 10. It has been found that a maximum drag reduction of approximately 10% occurs in fully developed turbulent flow. This figure is larger than the 6-8% drag reduction usually found for external flow. The maximum drag reduction occurred when the height of the riblets was between 7 and 13 wall units. Analysis of the developing region of the flow has shown a maximum drag reduction of approximately 8% at a wall unit value of 13, consistent with results in external flows. The effects of riblets on transition has also been investigated. It was found that riblets delayed transition by 2-4% in critical Re as measured by peak flatness, and caused some extension in the length of the transition process, so that the completion of transition was delayed by between 4-8%, with the stronger effect at the lower Reynolds numbers. Author (Herner)

A95-90278
CRITERIA FOR LOCATION OF VORTEX BREAKDOWN OVER DELTA WINGS
I. GURSUL University of Cincinnati, Cincinnati, OH, US
Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 985 May 1995 p. 194-196 Research supported by the US Air Force Office of Scientific Research
(HTN-95-01092) Copyright
Vortex breakdown phenomenon remains a challenging aspect of the flow over delta wings at high angle of attack. The observations of vortex breakdown and related interpretations for vortex tube experiments and delta wings are summarized in several review articles. The theoretical model of the phenomena are described in detail in References 1, 2, 3 and 7. These theoretical models are not complete enough to predict breakdown location over delta wings. The purpose of this note is to review several existing criteria and correlations for vortex breakdown over delta wings using a large database. Author (Herner)

A95-90279
THE VERIFICATION OF A THEORETICAL HELICOPTER ROTOR BLADE SAILING METHOD BY MEANS OF WINDTUNNEL TESTING
S. J. NEWMAN University of Southampton,
Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 982 February 1995 p. 41-51 Research supported by the DRA
(HTN-95-01093) Copyright
The performance of a helicopter rotor has always been dogged by the dissymmetry of air velocity over the blades caused by its translation in a direction substantially parallel to the plane of the rotor disc. Furthermore, in order to make the rotor even unstable, this dissymmetry of lift caused the introduction of major mechanical complications to the rotor hub. In forward flight the rotor is aerodynamically split into two halves either side of the flight direction. The advancing side, where the rotor rotation is in the same sense as the forward velocity, will see a greater dynamic head than the retreating side, where the rotor rotation and forward speed are in opposition. A rigid rotor would consequently suffer a major rolling moment and

if a viable proposition is to be achieved the rolling moment must be avoided. Provided that the rotor moves in an essentially edgewise manner, the problem created by the advancing and retreating sides cannot be avoided. It can, however, be isolated by the introduction of free (flapping) hinges to the rotor hub which allow the rotor blades to move in a direction normal to the rotor plane. With this introduction of freedom the rotor blade behavior is governed by two effects. The aerodynamic forces on the blade will generate a moment at the flapping hinge, and normally will be trying to move the blade out of the plane of rotation. As the blade flaps up, the centrifugal forces acting on it will then be able to oppose the aerodynamic moment with relatively minor deflections of the blades in flap. If a helicopter has to operate when this balance cannot be achieved then the blades will not be constrained in flap and the danger of large blade deflections must be considered. Operation on board ship, oil rig, or in appropriate geographical locations (the Falkland Islands in winter, for example) will cause considerable aerodynamic forces on the blade to be generated without the need of a high rotor speed and therefore without the controling forces on the blade. Under such circumstances considerable blade motion out of the plane of rotation can occur with the accompanying dangers. This behavior is known as blade sailing and, as can be appreciated, it is avoided if at all possible. By its nature, blade sailing is a considerable hazard to the airframe and ground/flight crews and there have been instances in the past where fatalities have occurred. To investigate it therefore an approach has to be taken which avoids full scale testing. Model scale testing is therefore the primary experimental procedure and a theoretical appraisal must also be conducted since the helicopter designer will need the ability to accurately predict this aeroelastic phenomenon and therefore determine the effect of its operational location. With this in mind, a set of experiments was conducted in the Department's main wind tunnels and a theoretical model was constructed to compare with the test results. Author (Herner)

A95-90280

CENTRAL-DIFFERENCE AND UPWIND-BIASED SCHEMES FOR STEADY AND UNSTEADY EULER AEROFOIL COMPUTATIONS

C. B. ALLEN University of Bristol, Bristol, UK Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 982 February 1995 p. 52-62
(HTN-95-01094) Copyright

Two numerical methods are presented for the computation of steady and unsteady Euler flows. These are applied to steady and unsteady flows about the NACA 0012 airfoil, using structured grids generated by the transfinite interpolation technique. An explicit central-difference scheme is produced on the cell-vortex method of Ni modified by Hall. The method is second-order accurate in time and space, and with flow quantities stored at boundaries the boundary conditions are simple to apply. This is a definite advantage over the cell-centered approach of Jameson, where extrapolation of the flow quantities is required at the boundaries, making unsteady boundary conditions difficult to apply. An explicit upwind-biased scheme is also produced, based on the flux-vector splitting of van Leer. The method adopts a three stage Runge-Kutta time-stepping scheme and a high-order spatial discretization which is formally third-order accurate for one-dimensional calculations. The upwind scheme is shown to be slightly more accurate than the central-difference scheme for steady airfoil flows. However, the central-difference scheme requires less than half the CPU time of the upwind-difference scheme, and hence is attractive, especially when considering three-dimensional flows. The transfinite interpolation technique is ideal for generating moving structured grids due to its simplicity, and grid speeds are available algebraically by the same interpolation as grid points. The method is also ideal for use in a multi-block approach. Author (Herner)

A95-90282

VISCOUS CONTRIBUTION TO THE HIGH MACH NUMBER DAMPING IN PITCH OF BLUNT SLENDER CONES AT SMALL ANGLES OF ATTACK

M. KHALID National Research Council, Canada Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 982 February 1995 p. 69-74
(HTN-95-01096) Copyright

The dynamic stability derivatives of blunt cones for small variations in angles of attack have been previously derived by the current author. However, no account of unsteady nature of the boundary layer was made in that work. In this paper closed form expressions for the increment in dynamic stability due to the presence of the boundary layer are derived by considering the pressure distribution perturbations as the boundary layer continuously adjusts to the enclosed oscillating body. The theory provides a first hand estimate of the complete pitch derivative damping without having to resort to more rigorous and expensive computational methods. Calculations performed at Mach numbers of 7 to 10 with axial positions ranging from 0.5 to 0.7 of the chord length for cones of semi-angle 10 deg and 20 deg, indicate that the effect of the boundary layer is to slightly reduce the magnitude of the inviscid damping derivative. For blunt cones at angles of attack less than 5 deg, this was in good agreement with the limited experimental data available. Author (Herner)

A95-90285

UNSTEADY AERODYNAMIC EFFECTS OF TRAILING EDGE CONTROLS ON DELTA WINGS

D. J. PILKINGTON University of Bath, Bath, UK and N. J. WOOD University of Bath, Bath, UK Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 983 March 1995 p. 99-108
(HTN-95-01099) Copyright

Effective control of combat aircraft at high angles of attack requires the flight control system to operate to high frequencies and gains. This increases the possibility of excitation of the structural modes by altering the aeroservoelastic stability of the complete system. This paper details the results of tests carried out on a rigid, 55 deg leading edge sweep delta wing, half model fitted with a half span elevon operated through a closed loop control system. The effects of steady elevon deflections up to 40 deg angle of attack are described. The unsteady pressures resulting from elevon oscillations at frequency parameters up to a typical combat aircraft have been measured. The effect of the elevon oscillation on the elevon itself and on the bending mode have been estimated by calculating the unsteady hinge and root bending moments about the wing root. The lower surface, unsteady elevon effects were found to be independent of incidence and frequency parameter. The amplitude of response of the weak vortex on the upper surface of the wing reduced rapidly with frequency parameter. Above an incidence of 10 deg, the vortex breackdown was above the wing and led to a further reduction in the vortex response. The vortex response lagged the elevon motion. Author (Herner)

A95-90446

HYPERSONIC SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTIONS IN THE VICINITY OF AN EXPANSION CORNER

M. E. WHITE Johns Hopkins Universit, Laurel, Maryland, US and D. A. AULT Johns Hopkins Universit, Laurel, Maryland, US 1995 7 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995 Research sponsored by the National Areospace Plane Joint Program Office
(AIAA PAPER 95-6125; HTN-95-B0365) Copyright

An experimental program has been conducted to investigate the behavior of hypersonic shock wave/turbulent boundary layer interactions in the vicinity of an expansion corner. Tests were run in the Calspan 96 inch shock tunnel at nominal Mach 11.5 free-stream conditions for a unit Reynolds number of approximately 17 million per foot. Fully turbulent boundary layers were generated with a flat plate, and oblique shocks were generated with a planar shock generator canted at angles of 10, 12, and 15 deg relative to the free stream. Shock impingement points were varied to create impingement points upstream, in the vicinity, and downstream of an expansion corner with an angle that was similar in magnitude to the shock generator. Wall static pressure and heat transfer were measured in the region of the shock interaction to determine the effects of the expansion corner on the character of the shock wave/boundary layer interaction. Detailed data has been generated for comparison with computational codes and to enable a better understanding of hypersonic inlet design. Author (revised by Herner)

A95-90447

TURBULENCE CHARACTERISTICS OF SUPERSONIC BOUNDARY LAYER PAST A BACKWARD FACING STEP

T. ARAI Muroran Institute of Technology, Muroran, Japan, H. SUGIYAMA Muroran Institute of Technology, Muroran, Japan, M. HOMAREDA Muroran Institute of Technology, Muroran, Japan, and N. UNO Muroran Institute of Technology, Muroran, Japan 1995 7 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995

(Contract(s)/Grant(s): MOESC-05650154; MOESC-06650186)

(AIAA PAPER 95-6126; HTN-95-B0366) Copyright

The aim of this paper is to clarify the turbulence characteristics of the supersonic boundary layers, which is reattaching downstream of a backward facing step. The boundary layer flow was analyzed by a two-dimensional laser Doppler velocimeter and flow visualizations. The results showed that there was a higher level of momentum exchange between the reattaching boundary layer flow and the main supersonic stream than that of over a flat plate case. Numerical simulation was conducted in this flow field, and the results were compared with the experimental ones. It was clarified that the present computation fluid dynamics (CFD) code exhibits a good of performance simulation for the mean characteristics of flow field. The turbulence data were analyzed from the point of view of the turbulence kinetic energy balance. The production, diffusion and transverse convection of turbulence energy were obtained experimentally. The relation of the coherent structure and turbulence kinetic energy was also discussed. Author (Herner)

A95-90455* National Aeronautics and Space Administration, Washington, DC.

HYPERSONIC AERODYNAMICS TEST FACILITY USING THE EXTERNAL PROPULSION ACCELERATOR

J. ROM Technion-Israel Institute of Technology, Haifa, Israel, M. LEWIS University of Maryland, College Park, Maryland, Israel, A. GUPTA University of Maryland, College Park, Maryland, Israel, and J. SABEAN University of Maryland, College Park, Maryland, Israel 1995 5 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995

(Contract(s)/Grant(s): NAGW-3715; N68171-94-C-9065)

(AIAA PAPER 95-6138; HTN-95-B0374) Copyright

The use of the External propulsion Accelerator (EPA) for launching models of hypersonic aerodynamic configurations into an instrumented ballistic range is discussed. The aerodynamic model is encased inside an axisymmetric projectile designed to be accelerated to high speed in the EPA. Accelerator lengths required to achieve hypersonic speeds are estimated to vary from 10 meters for Mach 7, 40 meters for Mach 10, 150 meters for Mach 15, and 700 meters for Mach 30, assuming a limit of 50,000 g's acceleration. For a model span of 10 cm to 25 cm, the launch tube diameters are 40 cm and 100 cm, respectively. Using this EPA launcher will enable exact simulation of hypersonic flight in ground facilities where both the gas composition and pressure can be controlled in the ballistic range. Author (revised by Herner)

A95-90469

COMPUTATION OF VORTEX FORMATION OVER ELAC-1 CONFIGURATION USING VORTICITY CONFINEMENT

J. STEINOFF University of Tennessee, Tullahoma, Tennessee, US and T. MERSCH University of Tennessee, Tullahoma, Tennessee, US 1995 19 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995

(AIAA PAPER 95-6157; HTN-95-B0388) Copyright

A new 'Vorticity Confinement' method is described which involves adding a term to the discretized momentum conservation equations of fluid dynamics. This term depends only on local variables and is zero outside vortical regions and viscous boundary regions. The partial differential equations with this extra term admit solutions which consist of Lagragian-like confined vortical regions in the shape of vortex filaments in 3-D, which convect with a fixed internal structure, without spreading, even if the equations contain diffusive terms. This modification appears to be useful in the numerical solution of flow problems involving thin vortical regions. Since only a fixed grid is used with local variables, the Vorticity Confinement method is quite general and can automatically accomodate vortical configurations and changes in vortex topology, such as merging. The 'Vorticity Confinement' method was used to calculate the vortex formation over the flight configuration ELAC-1. The fore-body of this configuration is essentially a delta wing with rounded leading edges. The leading edge vortices caused by the delta wing and a set of tip vortices generated by two vertical fins in the rear part of the configuration combine to form a complex vortical system. In this paper the results of the 3-D incompressible Navier-Stokes calculation over ELAC-1 are presented and compared to experimental data. Author (revised by Herner)

A95-90472

HYPERSONIC WAVERIDERS GENERATED FROM POWER-LAW SHOCKS

M. RASMUSSEN University of Oklahoma, Norman, Oklahoma, US and B. DUNCAN University of Oklahoma, Norman, Oklahoma, US 1995 9 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995

(AIAA PAPER 95-6160; HTN-95-B0391) Copyright

Hypersonic small-disturbance theory is used to analyze slender waveriders derived from axisymmetric flows past power-law shocks and bodies. The radii vary like z(exp m) where m is an index between 1/2 and 1. The analysis uses both exact and approximate self-similar inviscid solutions valid when the hypersonic similarity parameter is very large. A wide range of waverider shapes is allowed for in the formulation of the theory, which is oriented toward parametric studies. General expressions for the lift and drag are found in additions to the lift-to-drag ratio. It is found that inviscid power-law derived waveriders can produce larger lift-to-drag ratios than cone-derived waveriders with the same slenderness ratio. Author (revised by Herner)

A95-90751* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

BUFFETING TESTS IN A CRYOGENIC WINDTUNNEL

D. G. MABEY Imperial College, London, UK, R. P. BOYDEN NASA. Langley Research Center, Hampton, VA, US, and W. G. JOHNSON NASA. Langley Research Center, Hampton, VA, US Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 981 January 1995 p. 1-14

(HTN-95-92833) Copyright

Measurements of wing buffeting, using root strain gages, were made in the NASA Langley 0.3 m cryogenic wind tunnel to refine techniques which will be used in larger cryogenic facilities such as the United States National Transonic Facility (NTF) and the European Transonic Wind Tunnel (ETW). The questions addressed included the relative importance variations in frequency parameter and Reynolds number, the choice of model material (considering both stiffness and damping) and the effects of static aeroelastic distortion. The main series of tests was made on three half models of slender 65 deg delta wings with a sharp leading edge. The three delta wings had the same planform but widely differing bending stiffnesses and frequencies (obtained by varying both the material and the thickness of the wings). It was known that the steady flow on this configuration would be insensitive to variations in Reynolds number. On this wing at vortex breakdown the spectrum of the unsteady excitation is unusual, having a sharp peak at particular frequency parameter. Additional tests were made on one unswept half-wing of aspect ratio 1.5 with an NPL 9510 aerofoil section, known to be sensitive to variations in Reynolds number at transonic speeds. The test Mach numbers were M = 0.21 and 0.35 for the delta wings and to M = 0.30 for the unswept wing. On this wing the unsteady excitation spectrum is fairly flat (as on most wings). Hence correct representation of the frequency parameter is not particularly important. Author (Herner)

A95-90753
EFFECT OF SPHERICAL ROUGHNESS ELEMENTS UPON TRANSITION OF A 3-D BOUNDARY LAYER
M. O. CARPINLIOGLU University of Gaziantep, Turkey and O. T. GOEKSEL University of Gaziantep, Turkey Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 981 January 1995 p. 26-28 (HTN-95-92835) Copyright

The influence of isolated spherical roughness elements upon the transition of a three-dimensional boundary layer on a swept flat plate is discussed in this paper. Perturbations induced by the roughness are found to be more effective on the start of transition rather than the cross flow of the laminar undisturbed boundary layer at the roughness location. Author (Herner)

A95-90754
COLLECTIVELY VARIABLE INCIDENCE WINGTIPS FOR LIFT CONTROL AND REDUCED GUST SENSITIVITY
R. H. BARNARD Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 981 January 1995 p. 29-35
(HTN-95-92836) Copyright

This paper describes an investigation of the aerodynamic characteristics of collectively variable incidence wing tips at low speeds. Theoretical considerations supported by experimental measurements suggest that the use of articulated tips which can be rotated to a high incidence for low speed flight will decrease sensitivity to gusts. Furthermore, windtunnel measurements demonstrate that the use of very high tip incidences can produce an increment in maximum overall lift coefficient for some wing configurations. Another feature investigated is the possibility of utilising the lift increment for the purposes of direct lift control. The use of a radio controled model to test the practical viability of the concept is described. Author (Herner)

A95-91496
ESTIMATION OF AERODYNAMIC CHARACTERISTICS FOR THE VORTEX FLAPS BY THE SUCTION ANALOGY
KENICHI RINOIE National Aerospace Lab., Osawa, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 48-51
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Aerodynamic characteristics of the leading-edge vortex flap (LEVF) were estimated using a quasi-vortex lattice method coupled with the leading-edge suction analogy. Comparisons with experimental results indicated this method accurately predicts the resultant aerodynamic characteristics, although not when either the incidence or the flap deflection angle are large or when a separation region is formed inboard of the LEVF hinge line. Previous experiments found that at the maximum lift-to-drag (L/D) ratio, nearly smooth flow occurs on the tip of the flap surface without the occurrence of any large separation. Calculated results using the same wing configuration showed that at this maximum L/D ratio, the leading-edge suction force significantly decreases. This small leading-edge suction force is suggested to explain why no major leading-edge separation vortex occurs on the LEVF surface at the maximum experimentally determined L/D ratio. Author (Herner)

A95-91497
NUMERICAL EXPERIMENTS ON AERODYNAMIC HEATING MECHANISM IN SHOCK REFLECTION PROCESSES
SHIGERU ASO Kyushu Univ., Fukuoka, Japan, KENICHI OHYAMA Kyushu Univ., Fukuoka, Japan, and MASANORI HAYASHI Nishinippon Inst. of Tech., Fukuoka, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 52-55
Copyright

Numerical simulations on unsteady shock reflections by a ramp have been conducted in order to investigate unsteady aerodynamic heating due to shock reflection processes at a higher incident shock Mach number. The two-dimensional Navier-Stokes equations with a thin layer approximation are solved numerically by a TVD scheme. The effect of mesh refinement to the calculated results is investigated carefully. The results show the smaller mesh size is necessary for calculating precise aerodynamic heating loads and capturing the fine structure of the shock reflection patterns. Author (Herner)

A95-91498
NUMERICAL DESIGN METHODS FOR TRANSONIC NLF CONFIGURATIONS
J. HUA Northwestern Polytechnical Univ., Xian, China, Q. Z. YANG Northwestern Polytechnical Univ., Xian, China, D. K. XI Northwestern Polytechnical Univ., Xian, China, and Z. Y. ZHANG Northwestern Polytechnical Univ., Xian, China *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 56-59 Research sponsored by Science Foundation of Aeronautics and Commercial Aircraft, SEDC, and Chinese Aeronautical Establishment-DLR
Copyright

This paper represents computational fluid dynamics (CFD) methods for designing natural laminar flow (NLF) airfoils and wings directly under transonic viscous flow conditions. The two dimensional inverse code is coupled with an improved transonic airfoil analysis code which includes mixed laminar-turbulent boundary layer calculation, while the three dimensional inverse code coupled with a modified wing-body analysis code also consisting of mixed boundary layer corrections. The design examples of NLF airfoils and wings, including a forward-swept wing, show that the methods are capable to provide satisfactory results within a few design iterations. The wind tunnel tests of the designed contours support the numerical investigations. Author (Herner)

A95-91499
VORTEX LATTICE METHOD SIMULATION OF UNSTEADY FLOW DUE TO WING/EXTERNAL STORE COMBINATION
C. RUHI KAYKAYOGLU Technical Univ., Istanbul, Turkey, SALIH BOZKURT Technical Univ., Istanbul, Turkey, and CAN BAYAR Technical Univ., Istanbul, Turkey *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 60-63 Research sponsored by European Office of Aerospace Research and Development
Copyright

A nonlinear Computational Fluid Dynamics (CFD) technique based on an Unsteady Vortex Lattice Method (UVLM) is presented for treating the unsteady aerodynamics of wing/store/fuselage combination with wing tip and trailing edge separation in incompressible flow. A grid free approach based on the use of UVLM combined with a time dependent wing following and wake shedding procedure provides both transient and asymptotic wake shapes and wing loading. Transient lift development is found to be a function of external store location and size. The wake structure is altered under the continuous influence of the external store. The external store modifies the transient lift built up. The preliminary results show that the present code is capable of simulating the strong interaction between the trailing edge wake flow and underwing external store configuration with an accurate engineering estimation.
Author (Herner)

A95-91500
APPLICATION OF ACT TO UNSTABLE MOTIONS OF AN AIRFOIL IN GROUND EFFECT
KYOKO NITTA Nagoya Univ., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 64-67
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Linear quadratic regulator (LQR), linear quadratic Gaussian method (LQG), and H(sub infinity) method are applied on the ground effect problem. A two-dimensional flat plate airfoil is dealt with for simplicity. It is assumed that the airfoil is flying in the ground effect with 3 degrees of freedom (DOFs), plunging, pitching, and aileron pitching. The aeroelastic characteristics vary according to the altitude at which the airfoil is flying. On order to construct the control law which can be used in the required range of altitudes, the robustness is strongly required. As a preparatory study, the aerodynamic change is ex-

pressed as a plant noise. Under the presence of the uncertainty of the plant, controllers obtained with the H(sub infinity) method seems quite effective even in this early stage of a quasi-optimal problem.
Author (Herner)

A95-91507
AEROFOIL CHARACTERISTICS AT LOW REYNOLDS NUMBER
SHIGERU SUNADA Tokyo Univ., Japan and KEIJI KAWACHI Tokyo Univ., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 136-139 In JAPANESE
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Aerodynamic forces acting on a flat plate are measured during accelerated and steady motion. Aerodynamic characteristics of the flat plate at R(sub e) = 3 x 10(exp 3) are obtained during the steady motion. In addition, it is indicated during the accelerated motion that a quasi-steady assumption is not valid under high angle of attack and high reduced frequency (k(sub V) = 0.05 approximately 0.07). This is because separation is suppressed and a vortex from the leading edge exists near the upper surface of the wing. These results are useful for future analysis on a real insect flight.
Author (Herner)

A95-91508
HIGH SUBSONIC AND HIGH REYNOLDS NUMBER WIND TUNNEL TESTS OF TWO-DIMENSIONAL NATURAL-LAMINAR-FLOW AIRFOILS WITH SUCTION BOUNDARY LAYER CONTROL
MASAYOSHI NOGUCHI National Aerospace Lab., Japan, MAMORU SATO National Aerospace Lab., Japan, HIROSHI KANDA National Aerospace Lab., Japan, and YOJI ISHIDA National Aerospace Lab., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 140-143 In JAPANESE
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Wind tunnel tests in high subsonic and high Reynolds number flows were made for three natural-laminar-flow (NLF) airfoils with slotted, perforated and solid surface respectively to compare their drag characteristics when suction is applied or not. The Mach number was varied from 0.6 to 0.85 and the Reynolds number from 6 to 20 million. The results show that the net drag reduction of about 10% was attained by suction in spite of many severe adverse effects for laminarization in the wind tunnel test such as free stream turbulence and high Reynolds number effects. Author (Herner)

A95-91509
FIXED TRANSITION FOR SHOCK TUBE TRANSONIC FLOW
TARO AMEMIYA National Defense Academy, Japan, YUTAKA YAMAGUCHI National Defense Academy, Japan, KIYOHIDE SEKIMOTO Ishikawajima-Harima Heavy Industries Co. Ltd., Japan, and SHIGERU YAMAGUCHI Ishikawajima-Harima Heavy Industries Co. Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 144-147 In JAPANESE
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A shock tube test for an airfoil in transonic flows were performed to study trip strip effectiveness by means of Schlieren photographs for the freestream Mach number range of 0.76 to 0.84, and the Reynolds number range of 0.4 to 0.5 million. The angle of attack of the airfoil was fixed at 0 degrees. For the first step, two-dimensional type and six other modified types were tested for the trip strip. Some of them showed fairly good performance.
Author (Herner)

A95-91510
EXPERIMENTAL STUDY OF SHOCK/SHOCK INTERFERENCE HEATING ON A SWEPT CYLINDER
YOSHIHIRO HAMADA Kawasaki Heavy Industries Ltd., Japan, ATSUSHI KANEKO Kawasaki Heavy Industries Ltd., Japan, TAKASHI YAMAZAKI National Aerospace Lab., Japan, and KUNIO SOGA National Aerospace Lab., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 148-151 In JAPANESE
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This paper presents the experimental study of the influence of shock wave impingement on a swept cylinder model. The experiments were performed at Mach number of 10.8 in the National Aerospace Laboratory (NAL) shock tunnel and provided the detailed heat-transfer-rate distributions for swept angles of Lambda = 45 to approximately 60 deg. The primary purpose of this study is to obtain a peak heat-transfer-rate for each swept angle. The results show that the maximum peak heat-transfer-rate were obtained at Lambda = -10 deg and was about 20 times the undisturbed values. Author (Herner)

A95-91511
AN EXPERIMENTAL STUDY ON INTERACTING FLOW BETWEEN SUPERSONIC FLOW AND SECONDARY FLOW INJECTED NORMALLY THROUGH CIRCULAR NOZZLE
SHIGERU ASO Kyushu Univ., Japan, SATOSHI OKUYAMA Japan Air Lines Co. Ltd., Japan, SHOZO MAEKAWA Kyushu Univ., Japan, YASUNORI ANDO Ishikawajima-Harima Heavy Industry Co. Ltd., Japan, and TOSHIRO FUJIMORI Ishikawajima-Harima Heavy Industry Co. Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 152-155 In JAPANESE
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In the present study shock wave/turbulent boundary layer interaction regions induced by gaseous secondary flows injected into supersonic flows through circular nozzles are investigated carefully and the flow structure has been studied in detail. Experiments are conducted at freestream Mach number of about 3.8 total pressure of 1.3 MPa, total temperature, of about 300 K and Reynolds number based on the distance between the leading edge of the flat plate and the nozzle exit of 2 x 10(exp 7) under the almost adiabatic wall condition. In the experiments, the flow fields are visualized by the Schlieren method and surface pressure distributions are measured in the whole interaction region. The secondary flow is injected through slot nozzle or circular nozzle normal to the freestream. The total pressure ratio, P(sub c)/P(sub 0), (P(sub c): total pressure of injected secondary flow, P(sub 0): total pressure of free stream) and the width of the slot are varied and the changes of the flow field are investigated carefully. Quite remarkable flow characteristics are revealed. The present fundamental experiments can be quite important in order to provide a precise data set for the code validation of numerical simulations. Author (Herner)

A95-91512
AERODYNAMIC CHARACTERISTICS OF SUPERSONIC AIR-INTAKE/AIRCRAFT INTEGRATED MODELS
T. ITO National Aerospace Lab., Japan, A. MURAKAMI National Aerospace Lab., Japan, J. NODA National Aerospace Lab., Japan, S. SHINDO National Aerospace Lab., Japan, K. SAKATA National Aerospace Lab., Japan, H. SEKINE National Aerospace Lab., Japan, A. TATE National Aerospace Lab., Japan, M. WATANABE National Aerospace Lab., Japan, A. TANAKA Ishikawajima-Harima Heavy Industry Co. Ltd., Japan, and K. SHIRAISHI Ishikawajima-Harima Heavy Industry Co. Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 164-167 In JAPANESE
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A series of Mach 3 tests of the second model for air-intake/airframe integration problem was performed in National Aerospace Laboratory (NAL) M4 supersonic wind tunnel and the data was analyzed aerodynamically. The model of the air-intake with diverter is installed on the bottom surface of the airframe which was designed for Mach 3 flight. To investigate the difference of its compression type, this intake is the outer compression type against the mixed compression type intake at the first test. Schlieren method and oil-flow technique were applied for considering the flow structure around and on the model. Qualitative and some quantitative considerations on the effects of existence of the intake to the airframe aerodynamic coefficients were made clear. The aerodynamic force of the intake dramatically changed according to whether the intake was the outer compression type or the mixed compression type. Author (Herner)

A95-91513
A SINGULARITY METHOD FOR A TWO DIMENSIONAL STRATIFIED SHEAR FLOW
AKIO ICHIKAWA Civil Aviation Coll., Japan and KIMITAKA HIRANO Miyazaki Univ., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 168-171 In JAPANESE
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A method is developed for calculating the flow and the lift force on an airfoil with thickness in a parallel stream whose velocity and density vary exponentially in the vertical direction. An integral equation for the vortex distribution on the airfoil is obtained by using the fundamental solution which was derived by the authors. The integral equation is solved numerically. Computed results show the effect of shear parameters and density parameters on the characteristics of airfoils. Author (Herner)

A95-91514
OPTIMUM AERODYNAMIC DESIGN OF AIRCRAFT FUSELAGE USING BOUNDARY ELEMENT METHOD
SHIGEO MATSUMOTO Tokyo Univ., Japan and JUNZO SATO Tokyo Univ., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 172-175 In JAPANESE
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A general form of boundary element method for incompressible flow has been developed using Green's function, leading to an integral equation of the perturbation velocity potential, which, on the panel-divided surface, results in a set of linear algebraic equations. The pressure distribution on complete aircraft including wing, body, and tail can be found using the present method. An example of fuselage design problem for low drag is presented. Flexible modification of fuselage shape is obtained by using spline surfaces. Author (Herner)

A95-91515
A DETAILED EULER FLOW ANALYSIS OF TPS AND FANJET ENGINE
TATSURO UCHIDA Tokai Univ., Japan, NAOKI HIROSE National Aerospace Lab., Japan, and GORO BEPPU Tokai Univ., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 176-179 In JAPANESE
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Transonic axisymmetric Euler analysis for a fan-jet engine was carried out. Axisymmetric formulation was examined and improved compared with the previous report. It uses MacCormack's scheme in finite volume form. Two kinds of grid numbers were used and the results were compared (the number of grid points was 4440 and 17760). A detailed expansion-compression wave pattern in the supersonic exhaust region was captured. Author (Herner)

A95-91522
SOME CONSIDERATIONS ON SYSTEM DESIGN OF THE HYPERSONIC TRANSPORT AND SUPERSONIC AIR-INTAKES
KIMIO SAKATA National Aerospace Lab., Japan, RYOJI YANAGI National Aerospace Lab., Japan, and SHINJI HONAMI Science Univ. of Tokyo, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 216-219 In JAPANESE
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Among many technical subjects to be studied for hypersonic transport and/or the space plane, the optimization of the vehicle system to be similar to the hypersonic airbreathing engine is important and complex because many technical data of the components and subsystems, including the air-intake of the propulsion system are needed, even though the research is underway. Here, problems such as the integration of intake and airframe, engine matching and the system design of variable geometry intake for fitting to the air flow schedule, and typical result of the wind tunnel tests are presented. The turboramjet engine is mainly considered for Mach 5 flight. A candidate of the variable geometry, which includes the schedule of the ramp angle variation depending on the Mach number, is introduced. A result of the supersonic wind tunnel test at Mach 4.5 and computational fluid dynamics (CFD) of the models is also presented. Some of the results satisfy the target in the pressure recovery performance. The test results and analytical considerations show that the bleed system, optimized throat Mach number, well designed subsonic diffuser gave high performance of the intake. Author (Herner)

A95-91523
AN EXPERIMENTAL STUDY ON SUPERSONIC LAMINAR FLOW CONTROL
YASUHIRO TANI Fugi Heavy Industry Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 224-227 In JAPANESE
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An experimental study on supersonic laminar flow control with boundary layer suction was carried out. Wind tunnel tests were performed in the FHI 61 cm high speed wind tunnel on the swept wing model, having sweep angle of 45 and 65 degrees for supersonic and subsonic leading edge on the wing upper surface through perforated suction surface. Boundary layer transition location was detected by the visualization method using liquid crystals. Extensions of the laminar flow region were measured for various angles of attack, for both the supersonic and subsonic leading edge. Author (Herner)

A95-91524
EXPERIMENTAL STUDY FOR IMPROVING THE LIFT TO DRAG RATIO OF NEXT GENERATION SST
KENJI YOSHIDA Kawasaki Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 228-231 In JAPANESE
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In the aerodynamic design of Supersonic Transport (SST), improving the lift to drag ratio is very important. Kawasaki Heavy Industries has been studying aerodynamic design concepts which are related to the reduction of supersonic drag by using both wind-tunnel tests and computational fluid dynamics (CFD) analysis since 1988. Recently we designed a new SST configuration based on our previous results and investigated aerodynamic characteristics by wind tunnel tests. In this paper, we summarize typical results of our aerodynamic study. Author (Herner)

A95-91525
EXPERIMENTAL INVESTIGATION ON AEROTHERMODYNAMIC CHARACTERISTICS OF HYPERSONIC TRANSPORT
KOICHI HOZUMI National Aerospace Lab., Japan, SIGEAKI NOMURA National Aerospace Lab., Japan, YASUHIKO AIHARA Tokyo Univ., Japan, ETSUO MORISHITA Tokyo Univ., Japan, and TAKEO OKUNUKI Tokyo Univ., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 232-235 In JAPANESE
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The Hypersonic Transport (HST) long cruising times, combined with the need for a low-drag and high lift to drag (L/D) configuration, results in a severe aerothermodynamics environment. To achieve low drag and high L/D, the vehicle must have a relatively sharp nose and wing leading edges. Some aerothermal design aspects of HST with configuration of sharp-leading edge and of high L/D aerodynamic characteristics are presented based on heat transfer measurement tests on a hypersonic transport and flat plates at the National Aerospace Laboratory (NAL) hypersonic wind tunnel. Surface temperature distributions corresponding to the flight conditions of HST were considered based on the experimental results. The present investigation showed that some actively-cooled leading will be necessary because of the high heating rate in the leading edge region. And the investigation also showed that radiative cooling should be effective over large areas of the vehicle because of the relatively low estimated fuselage surface temperature level. Effect of angle of attack and wing sweep angle on aerodynamic heating in the leading-edge region and the boundary layer transition on the compression surface of the model were also examined. Author (Herner)

A95-91538

A SHOCK TUNNEL TEST OF A WINGED HYPERSONIC RESEARCH VEHICLE

MASAO SHIROUZO National Aerospace Lab., Japan, TAKASHI YAMAZAKI National Aerospace Lab., Japan, TAKESHI ITO National Aerospace Lab., Japan, SHIGEYA WATANBE National Aerospace Lab., Japan, YASUHIRO WADA National Aerospace Lab., Japan, SHINJI NAGAI National Aerospace Lab., Japan, and AKIRA MURAKAMI National Aerospace Lab., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 314-317 In JAPANESE

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A hypersonic flight experiment (HYFLEX), which is one of the flight experiment series preceding to the development of a Japanese spaceplane, HOPE (H-2 Orbiting Plane), is planned to be performed in FY 1995 as a collaborative project between the National Aerospace Laboratory (NAL) and the National Space Development Agency (NASDA). The aerodynamic characteristics of a candidate configuration of the research vehicle was investigated at Mach 10.8 and angles of attack from 0 to 45 deg by using NAL Middle Scale Shock Tunnel. The effects of vertical tail configuration and deflection angle of aerodynamic surfaces on the aerodynamic characteristics were tested. The effect of viscous interaction was investigated as well. Author (Herner)

A95-91552

A METHOD FOR CALCULATING MEAN AERODYNAMIC CENTER AND ZERO-LIFT MOMENT COEFFICIENT OF AIRCRAFT WITHOUT TAIL BY USING MEASURED FLIGHT LOADS

XI CAO Osaka Prefecture Univ., Sakai, Japan and YOSHIHIKO SUGIYAMA Osaka Prefecture Univ., Sakai, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 414-417 In JAPANESE

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This paper presents a new method for estimating mean aerodynamic center and zero-lift moment coefficient of the aircraft without tail by using actual measured flight data. The paper first describes the basic principle of the proposed method and secondly demonstrates the effectiveness of the method by comparing the results by the propsed method and those obtained by wind tunnel data. Author (Herner)

A95-91557

LOW SPEED WIND TUNNEL BLOCKAGE CORRECTIONS FOR AIRFOILS AT MEDIUM TO LARGE ANGLES OF ATTACK

K. R. REDDY Indian Inst. of Science, Bangalore, India and G. N. V. RAO Indian Inst. of Science, Bangalore, India *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 434-437

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Classical methods of corrections for solid and wake blockages are well known and are applicable for streamlined bodies at low angles of attack with attached flow. Methods of corrections for bluff bodies, first proposed by Maskell and later modified by Modi and Sherbiny and others have some limitations. However, the issue seem to be not fully settled when the body can neither be called as streamlined nor as classically bluff. Towards clarifying this issue, experiments were conducted on three airfoils and five flat plates, in three different wind tunnels at angles of attack from zero to ninety degrees covering a range of blockage ratios up to thirty five percent. The results of these experiments when plotted show, clearly, that the linear relationship (drag coefficient versus the product of drag coefficient and blockage ratio), implicit in Maskell's theory, exists only beyond an angle of attack of thirty five degrees, with the relationship being definitely nonlinear below this value. This observation suggests that Maskell's method of correction as modified by Modi and Sherbiny, Ashill and Keating, etc. are applicable for streamlined bodies for angles of attack more than thirty five degrees only. For angles below thirty five degrees, it appears at the present time, the the nonlinear graph indicated by the above experimental results has to be used. Author (Herner)

A95-91558

USE OF PARTIALLY OPEN WIND TUNNEL WALLS FOR BLOCKAGE-FREE SEPARATED FLOWS ON BODIES

J. DHEENADAYALAN Madras Inst. of Tech., Anna Univ., Madras, India and G. N. V. RAO Indian Inst. of Science, Bangalore, India *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 438-441

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The technique of partially opening the top and bottom walls of a solid wall wind tunnel to obtain blockage-free forces in two-dimensional separated flows is examined by using free streamline theory. Sato's model of the far downstream vertical separation (displacement) of the two arms of the separated stagnation streamline, with a singular surface to model the reattachment zone and separate the bubble attached to the body from the fully flowing fluid in the wake, is used. Results for a symmentric wedge suggests that blockage-free forces can be obtained with partial wall opening. It is suggested that the opening at which the value of the bubble pressure in the real viscous flow with partial opening of the walls equals the theoretical blockage-free bubble pressure at the same partial wall opening, be taken as the required wall opening. Author (Herner)

A95-91562

EXPERIMENTAL STUDY OF THE AERODYNAMIC CHARACTERISTICS OF THE COUNTER-ROTATION PROPELLERS

KANICH AMANO Japan Aircraft Development Corp., Japan, HIDEO HOSHINO National Aerospace Lab., Japan, KATSUICHI MUROTA National Aerospace Lab., Japan, MASATAKA HASHIDATE National Aerospace Lab., Japan, ATSUSHI KANEKO Kawasaki Heavy Industries Ltd., Japan, SHINGO NAKAMURA Kawasaki Heavy Industries Ltd., Japan, KATSUYA SAITO Kawasaki Heavy Industries Ltd., Japan, and SHINICHI KANEKO Kawasaki Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 458-461 In JAPANESE

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Counter-rotating propellers (CRP) are expected to be a high thrust efficiency propulsion system. JADC and National Aerospace Laboratory have investigated the testing technique and power effects through a half model wind tunnel test and an engine unit wind tunnel test using the CRP simulating the unducted fan. This paper reports the aerodynamic characteristics of the CRP under parameters of advance ratio J, blabe pitch angle Beta(sub F), Beta(sub A), and angle of attack alpha. Author (Herner)

A95-91563

WAKE VELOCITY MEASUREMENT OF COUNTER-ROTATION PROPELLERS

MASATAKA HASHIDATE National Aerospace Lab., Japan, HIROFUMI KONDO National Aerospace Lab., Japan, SHIGEO KAYABA National Aerospace Lab., Japan, OSAMU NONAKA National Aerospace Lab., Japan, KANICHI AMANO Japan Aircraft Development Corp., Japan, SHINGO NAKAMURA Japan Aircraft Development Corp., Japan, MASAYUKI KIMOTO Kawasaki Heavy Industries Ltd., Japan, and SHINICHI KANEKO Kawasaki Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba,

Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 462-465 In JAPANESE
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A test was conducted to determine the basic performance and wake flow-field of counter-rotating propellers. The results were obtained as follows: (1) The velocity ratio (V(sub X)/V(sub infinity)) in the core is proportional to the thrust coefficient; (2) The velocity ratio (V(sub X)/V(sub infinity)) in the core is symmetric to theoretical axis; and (3) The swirl flow has the same rotational direction as the rear blade from 0.1 R to 0.8 R and the opposite direction from 0.8 R to 1.0 R, respectively. Author (Herner)

A95-91564
EXPERIMENT OF THE LARGE ELASTIC DEFORMATION OF BICONVEX WING SECTIONS IN AN AIR-FLOW
AKIYOSHI MINEO Chiba Polytechnic Coll., Chiba, Japan and MITUO MAKINO College of Science and Engineering, Nihon Univ., Chiba, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 466-469 In JAPANESE
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It is assumed that airplane efficiency can be improved through deforming the wing sections to fit best to each flight stage such as takeoff, landing, or cruising. This paper is on a part of our basic studies and experiment to test our assumption. The experiment is made in a wind tunnel on biconvex wing sections with curved plates of uniform thickness. We measured how the wing sections are deformed in relation to the outer wind pressure through the airflow and the pressure on the inside. Author (Herner)

A95-91568
NEURAL NETWORK APPROACH TO IDENTIFICATION OF AERODYNAMIC LOADS ON A WING. 1: APPLICATION TO CANTILEVERED BEAM MODELS
XI CAO Osako Prefecture Univ., Japan, Y. SUGIYAMA Osako Prefecture Univ., Japan, R. ISIDA Osako Prefecture Univ., Japan, and T. KATAYAMA Osako Prefecture Univ., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 482-485 In JAPANESE
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The intended aim of the study is to develop the neural network approach to the identification of aerodynamic loads acting upon the aircraft wing. As the first step of the study, the paper describes the application of the neural network to the identification of the load distribution upon cantilevered beam models. A distributed load is approximated by a system of a finite number of concentrated loads. The paper demonstrates the applicability of the neural network to the load identification in beam models. Author (Herner)

A95-91673
HIGH ANGLE OF ATTACK MISSLE AERODYNAMICS
P. C. DEXTER British Aerospace Plc, UK 1991 5 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 3: Aerodynamics for the Future)
(CONGRESS PAPER C428-3-060; HTN-95-21104) Copyright

A major influence in the aerodynamics of missiles is the significant amount of separated flow encountered for most flight conditions. At high angles of attack the flow may become unpredictably asymmetric, even on geometricly symmetric configurations, with resultant possible control problems. Accurate and easy modeling of such flows is extremely difficult and beyond present capabilities. Author (Herner)

A95-91674
KINETIC HEATING IN HYPERSONIC FLIGHT
R. HILLIER 1991 6 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 3: Aerodynamics for the Future)
(CONGRESS PAPER C428-3-056; HTN-95-21105) Copyright

This paper presents a brief introduction to boundary layer kinetic heating at hypersonic speeds, illustrated by three problems: the effect of nose blunting on boundary layer development on a slender cone; base flow separation; and shock induced separation at a compression corner. These are selected as well defined flows, and although they are all formed by two-dimensional geometries they illustrate some features expected on three-dimensional configurations. Author (Herner)

A95-91694
RECENT RESEARCH IN ASTOVL AIRCRAFT GROUND ENVIRONMENT
K. KNOWLES 1991 8 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 9: Future Aerodynamic Concepts & Equip.)
(CONGRESS PAPER C428-9-040; HTN-95-21125) Copyright

A brief survey is presented of the aerodynamic phenomena associated with jet-lift aircraft in ground effect. The particular problems of modeling the ground vortex formed by impinging jets in cross-flows are then described, in the light of the authors' own experimental studies. Finally, areas of these flow-fields exhibiting stochastic properties are highlighted. Author (Herner)

A95-91695
COST EFFECTIVE SMALL-SCALE EXPERIMENTS TO AID THE DESIGN OF ASTOVL AIRCRAFT
D. N. ING and P. BAILEY 1991 5 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 9: Future Aerodynamic Concepts & Equip.)
(CONGRESS PAPER C428-9-098; HTN-95-21126) Copyright

A number of studies are presented which highlight the cost effectiveness of small-scale experiments on new ASTOVL aircraft concepts. Careful planning, and an industrially-experienced analysis led to wide range of insights and understanding of this complex problem. Author (Herner)

A95-91697
THE USE OF HOT FILM FOR THE INVESTIGATION OF BOUNDARY-LAYER TRANSITION
L. GAUDET, C. J. BETTS, and P. R. ASHILL 1991 4 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 9: Future Aerodynamic Concepts & Equip.)
(CONGRESS PAPER C428-9-199; HTN-95-21128) Copyright

The constant temperature hot-film technique has been used to investigate the transition region on a modified flat plate and a large two-dimensional wing. Time histories and root mean square (rms) values of the output signals together with the power spectral density (PSD) clearly indicate the build up of energy associated with the development of Tollmien-Schlichting waves prior to onset of transition. A large increase in the low-frequency energy content of the spectrum occurs at the onset of the transition. Measurements of skin friction through the transition region have been obtained based on the mean heat loss of the hot film. Author (Herner)

A95-91895
SIMILARITY SOLUTIONS FOR HYPERSONIC FLOW PAST SLENDER BODIES OF REVOLUTION AT SMALL INCIDENCE
HAMDI T. HEMDAN King Saud Univ., Riyadh, Saudi Arabia Acta Astronautica (ISSN 0094-5765) vol. 35, no. 8 April 1995 p. 501-508
(HTN-95-12195) Copyright

Similarity solutions for hypersonic flow past slender pointed-nose bodies of revolution at small angles of attack are obtained in this paper. A linear perturbation technique is applied to a newly developed hypersonic theory using a transformed angle of attack as the perturbation element. This linear perturbation is followed by a second, also linear, perturbation in the surface curvature, and the final approximate equations are obtained as ordinary differential equations. The present approach has the new feature of the absence of a vortical layer and is regular at the body surface and over the entire flowfield. Results for the surface pressure, the coefficient of normal force and the shock wave of ogive bodies and circular

cones are compared with other approximate theories and experiments and the agreement is found to be reasonable.
Author (Herner)

N95-28708 ESDU International Ltd., London (England).
COMPUTER PROGRAM FOR ESTIMATION OF LEADING-EDGE SUCTION DISTRIBUTION FOR PLANE THIN WINGS AT SUBSONIC SPEEDS
Dec. 1994 5 p
(ISSN 0141-397X)
(ESDU-94038; ISBN-0-856-79925-4) Avail: ESDU

ESDU 94038 introduces a Fortran program, ESDUpac A9438, that calculates the total theoretical leading-edge suction and its normalized spanwise distribution for wings from the tabulated values for the distribution given in ESDU 94037, making any necessary interpolations. It applies to wings with unswept or swept back leading-edges. The input to and output from the program are explained and illustrated by a worked example and the program is provided on disc (uncompiled) in the software volume. ESDU

N95-28720*# Wyle Labs., Inc., Arlington, VA.
THE ACOUSTIC CHARACTERISTICS OF TURBOMACHINERY CAVITIES Final Contractor Report
M. J. LUCAS, R. NOREEN, L. D. SOUTHERLAND, J. COLE, III (Cambridge Acoustical Associates, Inc., Cambridge, MA.), and M. JUNGER (Cambridge Acoustical Associates, Inc., Cambridge, MA.) Washington NASA May 1995 308 p
(Contract(s)/Grant(s): NAS8-37360)
(NASA-CR-4671; M-778; NAS 1.26:4671) Avail: CASI HC A14/MF A03

Internal fluid flows are subject not only to self-sustained oscillations of the purely hydrodynamic type but also to the coupling of the instability with the acoustic mode of the surrounding cavity. This situation is common to turbomachinery, since flow instabilities are confined within a flow path where the acoustic wavelength is typically smaller than the dimensions of the cavity and flow speeds are low enough to allow resonances. When acoustic coupling occurs, the fluctuations can become so severe in amplitude that it may induce structural failure of engine components. The potential for catastrophic failure makes identifying flow-induced noise and vibration sources a priority. In view of the complexity of these types of flows, this report was written with the purpose of presenting many of the methods used to compute frequencies for self-sustained oscillations. The report also presents the engineering formulae needed to calculate the acoustic resonant modes for ducts and cavities. Although the report is not a replacement for more complex numerical or experimental modeling techniques, it is intended to be used on general types of flow configurations that are known to produce self-sustained oscillations. This report provides a complete collection of these models under one cover. Author

N95-28723*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SURFACE MODELING, GRID GENERATION, AND RELATED ISSUES IN COMPUTATIONAL FLUID DYNAMIC (CFD) SOLUTIONS
YUNG K. CHOO, comp. Mar. 1995 832 p Workshop held in Cleveland, OH, 9-11 May 1995
(Contract(s)/Grant(s): RTOP 505-62-52)
(NASA-CP-3291; E-9458; NAS 1.55:3291) Copyright Avail: CASI HC A99/MF A10

The NASA Steering Committee for Surface Modeling and Grid Generation (SMAGG) sponsored a workshop on surface modeling, grid generation, and related issues in Computational Fluid Dynamics (CFD) solutions at Lewis Research Center, Cleveland, Ohio, May 9-11, 1995. The workshop provided a forum to identify industry needs, strengths, and weaknesses of the five grid technologies (patched structured, overset structured, Cartesian, unstructured, and hybrid), and to exchange thoughts about where each technology will be in 2 to 5 years. The workshop also provided opportunities for engineers and scientists to present new methods, approaches, and applications in SMAGG for CFD. This Conference Publication (CP) consists of papers on industry overview, NASA overview, five grid technologies, new methods/ approaches/applications, and software systems. For individual titles, see N95-28724 through N95-28775.

N95-28731*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ALGORITHMS FOR HIGH ASPECT RATIO ORIENTED TRIANGULATIONS Abstract Only
MARY-ANNE K. POSENAU *In* NASA. Lewis Research Center, Surface Modeling, Grid Generation, and Related Issues in Computational Fluid Dynamic (CFD) Solutions p 88 Mar. 1995
Avail: CASI HC A01/MF A10

Grid generation plays an integral part in the solution of computational fluid dynamics problems for aerodynamics applications. A major difficulty with standard structured grid generation, which produces quadrilateral (or hexahedral) elements with implicit connectivity, has been the requirement for a great deal of human intervention in developing grids around complex configurations. This has led to investigations into unstructured grids with explicit connectivities, which are primarily composed of triangular (or tetrahedral) elements, although other subdivisions of convex cells may be used. The existence of large gradients in the solution of aerodynamic problems may be exploited to reduce the computational effort by using high aspect ratio elements in high gradient regions. However, the heuristic approaches currently in use do not adequately address this need for high aspect ratio unstructured grids. High aspect ratio triangulations very often produce the large angles that are to be avoided. Point generation techniques based on contour or front generation are judged to be the most promising in terms of being able to handle complicated multiple body objects, with this technique lending itself well to adaptivity. The eventual goal encompasses several phases: first, a partitioning phase, in which the Voronoi diagram of a set of points and line segments (the input set) will be generated to partition the input domain; second, a contour generation phase in which body-conforming contours are used to subdivide the partition further as well as introduce the foundation for aspect ratio control, and; third, a Steiner triangulation phase in which points are added to the partition to enable triangulation while controlling angle bounds and aspect ratio. This provides a combination of the advancing front/contour techniques and refinement. By using a front, aspect ratio can be better controlled. By using refinement, bounds on angles can be maintained, while attempting to minimize the number of Steiner points. Derived from text

N95-28743*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN UNSTRUCTURED-GRID SOFTWARE SYSTEM FOR SOLVING COMPLEX AERODYNAMIC PROBLEMS
NEAL T. FRINK, SHAHYAR PIRZADEH (Vigyan Research Associates, Inc., Hampton, VA.), and PARESH PARIKH (Vigyan Research Associates, Inc., Hampton, VA.) *In* NASA. Lewis Research Center, Surface Modeling, Grid Generation, and Related Issues in Computational Fluid Dynamic (CFD) Solutions p 289-308 Mar. 1995
Avail: CASI HC A03/MF A10

A coordinated effort has been underway over the past four years to elevate unstructured-grid methodology to a mature level. The goal of this endeavor is to provide a validated capability to non-expert users for performing rapid aerodynamic analysis and design of complex configurations. The Euler component of the system is well developed, and is impacting a broad spectrum of engineering needs with capabilities such as rapid grid generation and inviscid flow analysis, inverse design, interactive boundary layers, and propulsion effects. Progress is also being made in the more tenuous Navier-Stokes component of the system. A robust grid generator is under development for constructing quality thin-layer tetrahedral grids, along with a companion Navier-Stokes flow solver. This paper presents an overview of this effort, along with a perspective on the present and future status of the methodology. Derived from text

N95-28800 ESDU International Ltd., London (England).
LEADING-EDGE SUCTION DISTRIBUTION FOR PLANE THIN WINGS AT SUBSONIC SPEEDS
Nov. 1994 58 p
(ISSN 0141-397X)
(ESDU-94037; ISBN-0-85679-924-6) Avail: ESDU

ESDU 94037 gives an expression for calculating the total theoretical leading-edge suction force using the lift-curve slope and the lift-dependent drag factor which can be obtained respectively from ESDU 70011 and 74035. The normalized spanwise distribution of suction for plane straight-tapered wings is tabulated, and illustrated in graphs, for a systematic set of planforms that allows the distribution to be obtained for any wing by cross plotting the tabulated results. The results were obtained from runs of a vortex-lattice program but special modelling was necessary for certain difficult planforms such as those of low taper ratio and low aspect ratio, and also in the vicinity of the centre-line chord, to ensure a coherent set of normalized distributions. Details of the corrections are included. A computer program, ESDUpac A9438, is introduced in ESDU 94038, which incorporates all the corrected tabulated data, carries out any interpolation required to obtain the distribution for the chosen planform and calculates the total suction force. The expected accuracy of the results is discussed. Author

N95-28885 ESDU International Ltd., London (England).
INCREMENTS IN AEROFOIL LIFT COEFFICIENT AT ZERO ANGLE OF ATTACK AND IN MAXIMUM LIFT COEFFICIENT DUE TO DEPLOYMENT OF A PLAIN TRAILING-EDGE FLAP, WITH OR WITHOUT A LEADING-EDGE HIGH-LIFT DEVICE, AT LOW SPEEDS
Dec. 1994 15 p
(ISSN 0141-397X)
(ESDU-94028; ISBN-0-85679-915-7) Avail: ESDU

ESDU 94028 presents an estimation method based on first approximations from the theory for a thin hinged plate modified using empirical correlation factors to account for the geometry of practical aerofoils and high-lift devices. To allow for the effects of chord extension, the flap chord ratio and lift coefficients are based on an aerofoil extended chord. The data for aerofoils with trailing-edge flaps deployed from which the methods were developed were extracted from wind-tunnel tests reported in the literature covering a wide range of practical geometries. Fewer data were available for aerofoils with both leading- and trailing-edge devices deployed. The methods apply to Reynolds numbers greater than a million and freestream Mach numbers less than 0.2. The predicted and test data for the lift coefficient increments at zero angle of attack and at maximum lift are correlated to within 20 percent. The use of the methods is illustrated by worked examples. To obtain results for an aerofoil with both leading-edge devices and plain flaps deployed, ESDU 84026 is used in conjunction with this document and ESDU 94027. ESDU

N95-28897 ESDU International Ltd., London (England).
EXCRESCENCE DRAG LEVELS ON AIRCRAFT
Nov. 1994 34 p
(ISSN 0141-4054)
(ESDU-94044; ISBN-0-856-79931-9) Avail: ESDU

ESDU 94044 is based on manufacturer's estimated values for a large number of aircraft as manufactured and provides a guide to standards that have been achieved and a method to obtain a first approximate estimate. In most cases a datum drag parameter is presented at the troposphere and a Mach number of 0.8; a correction factor to other altitudes and speeds whose derivation is included is based on a detailed study of the variation of excrescence drag with Reynolds and Mach numbers. The drag parameter is plotted against wetted area for complete airframes but, for a more detailed estimate, values for some categories of excrescence are also given graphically. They are: surface and control imperfections, air-data systems, lights and beacons, antennas, static discharge wicks, auxiliary power unit, and features required for rain dispersal, for ventilation/cooling, for air-conditioning and for fuel systems. Some information is included on the extent that 'clean-up' has proved possible on several aircraft. Author

N95-28904 ESDU International Ltd., London (England).
SURFACE PRESSURE COEFFICIENT DISTRIBUTIONS FOR AXISYMMETRIC FORECOWLS AT ZERO INCIDENCE (M SUB INFINITY LESS THAN OR EQUAL TO 1.5)
Jun. 1994 78 p
(ISSN 0141-4356)
(ESDU-94015; ISBN-0-85679-902-5) Avail: ESDU

ESDU 94015 presents charts for 20 cowls of the distributions computed from finite difference solutions to the Euler equations for inviscid compressible flow. Computed shock waves are smeared over a few mesh cells which should give correct shock pressure jumps. The results are shown as functions of freestream Mach number and mass flow ratio. Data are presented for the same cowls and flow conditions as in ESDU 94014 which gives corresponding values of coefficients of wave drag, pre-entry force and forecowl pressure force. Sixteen cowls have NACA 1-series external profile, with differing combinations of diameter ratio and fineness ratio. The remaining four have fixed diameter ratio and fineness ratio but external profiles that differ systematically from the NACA I-series profile. Author

N95-28921# Notre Dame Univ., IN. Dept. of Aerospace and Mechanical Engineering.
THE EFFECTS OF THREE-DIMENSIONAL IMPOSED DISTURBANCES ON BLUFF BODY NEAR WAKE FLOWS: EFFECTS OF TAPER AND SPLITTER PLATES ON THE NEAR WAKE CHARACTERISTICS OF A CIRCULAR CYLINDER IN UNIFORM AND SHEAR FLOW Final Report
ELGIN A. ANDERSON and ALBIN A. SZEWCZYK Apr. 1994 320 p
(Contract(s)/Grant(s): N00014-90-J-4083)
(AD-A292113) Avail: CASI HC A14/MF A03

The near wake characteristics of a circular cylinder were modified by use of splitter plates, cylinder taper, and shear flow to investigate the relationship between the various near wake parameters. The results are based on hot wire and mean pressure measurements, flow visualization of the near wake, and linear stability analysis of the shear layer. The straight cylinder variation in Strouhal number with respect to splitter plate length was divided into four regions identified by the flow phenomenon that dominates the shedding frequency selection namely, stabilizing, shear layer elongation, reduced entrainment, and splitter plate-vortex interaction. A sinuous plate increased the 2-dimensionality of the shear layer compared to the straight plate and affected the spanwise coherence of the Karman vortices. However, within the formation region the sinuous splitter plate produced results similar to those produced by a straight plate of equal average length. DTIC

N95-29091# Washington State Univ., Pullman, WA. Dept. of Mechanical and Materials Engineering.
INTERACTIONS OF SPANWISE AND CHORDWISE VORTICITY ASSOCIATED WITH THREE-DIMENSIONAL DYNAMIC STALL OVER AN OSCILLATING WING Final Report, 15 Feb. 1991 - 15 Aug. 1994
B. R. RAMAPRIAN 15 Oct. 1994 19 p
(Contract(s)/Grant(s): DAAL03-91-G-0026)
(AD-A290546; ARO-28159.9-EG) Avail: CASI HC A03/MF A01

This is the final report on the experimental research performed under U.S. Army Research Office Grant No. DAAL 03-91-0026, with Dr. Thomas Doligalski as the Technical Program Manager. The Principal Investigator was B.R. Ramaprian. The research work involved the measurement of the pressure and velocity fields in the three-dimensional flow field surrounding and in the wake of the tip region of a rectangular wing of NACA 0015 profile. Measurements were made both with the wing stationary and with the wing oscillating sinusoidally in pitch about its quarter-chord axis. Pressure transducers and three-component laser Doppler velocimetry were used in these measurements. The results have been used to understand the vorticity dynamics in three-dimensional steady and unsteady flows. The study is relevant to helicopter rotor aerodynamics. All the data have been archived and are available for use by any interested reader. DTIC

N95-29094 Minnesota Univ., Minneapolis, MN.
STUDIES IN DRAG REDUCTION Ph.D. Thesis
CHRISTODOULOS CHRISTODOULOU 1994 165 p
Avail: Univ. Microfilms Order No. DA9415476

Drag reduction due to riblets (streamwise longitudinal grooves) in fully developed turbulent flows in pipes and cylindrical Couette flows is established and shown to have similar characteristics. The maximum drag reduction is about eight percent and occurs when the riblet spacing (which in this case is equal to the riblet height) when expressed in wall units is about 11 to 16. This correlates well with the Taylor microscale of the fluctuating velocity gradient in the spanwise direction. The Taylor microscale was shown by Kailasnath and Sreenivasan to be approximately equal to the mean value of the zero-crossing scale of a random signal and our result was interpreted as a signal being influenced most through its zero-crossing scale. The combined effects of riblets and dilute polymer solutions in drag reduction in pipes is examined and the results show a superposition of drag reduction (but not additive) that depends on the kind of polymer used and its concentration. Some additions to the wave speed meter are reported as well as new wave speed data. A possibility of drag reduction in dilute polymer solutions being a change of type phenomenon is stated. Finally friction factors versus Reynolds number curves are computed using the k-e model for perfect core annular flow of water and crude oil in pipes.
Dissert. Abstr.

N95-29102 Florida State Univ., Gainesville, FL.
PIV INVESTIGATION OF COMPRESSIBILITY EFFECTS ON DYNAMIC STALL Ph.D. Thesis
WILLIAM PAUL CRISLER 1993 164 p
Avail: Univ. Microfilms Order No. DA9413277

An experimental investigation was conducted to study compressibility effects on dynamic stall for an airfoil pitching at a constant rate. Instantaneous, whole field velocity data was acquired using an on-line, video-based particle image velocimetry (PIV) system, which incorporated a passive, optical, displacement bias technique to eliminate the sign ambiguity inherent in PIV measurements of reversed flows. Vorticity data was subsequently computed from the corresponding velocity field. Free stream Mach numbers were 0.23 and 0.45, and corresponding Reynolds numbers were 280,000 and 620,000, respectively. Nondimensional pitch rates were 0.010, 0.030, and 0.060. Although the flow was near sonic in the high speed case, no shocks were observed. The sequence of events at high speed was remarkably similar to that at both low speed and to that observed in water tank experiments. The dynamic stall process is initiated with formation and convection aft of a single, discrete, vortex. Formation and initial release of the structure is probably initiated by a van Dommelen-Shen unsteady separation. A region of closed vorticity forms over the forward portion of the airfoil, caused by periodic reattachment and shedding of discrete vortical structures of positive sign from the leading edge. These structures and the adverse pressure gradient then induce production of negative vorticity near the airfoil surface, which is convected forward and accumulates near the quarter chord. Subsequently, coherent negative vorticity is ejected into the outer flow, isolating the initial structures from the leading edge. Subsequent interaction induces separation from the surface of the dynamic stall vortex, which is composed of several small, interacting structures rather than a single, large structure. The data complement Schlieren and surface pressure investigations, which are useful but provide no information about local flow direction. The data also demonstrate the utility of PIV for investigating highly unsteady, reversed flows with dynamic boundary conditions at compressible or transonic speeds. Dissert. Abstr.

N95-29108 Georgia Inst. of Tech., Atlanta, GA.
A VORTICITY-VELOCITY APPROACH FOR THREE-DIMENSIONAL UNSTEADY VISCOUS FLOW OVER WINGS Ph.D. Thesis
GOO KIM 1993 271 p
Avail: Univ. Microfilms Order No. DA9415648

A computational method for the simulation of three-dimensional unsteady viscous flows is presented in this thesis. Particular attention is given to the three-dimensional application of the integro-differential formulation for the Navier-Stokes flows. This formulation has some salient features, including the capability of the 'zonal solution,' which are believed to be still useful for efficient and accurate computation of three-dimensional flow. Satisfaction of the constraint of no vorticity divergence in computation is emphasized for the stable convergence of a steady flow solution as well as for the physical validity of the solution. It is shown that the constraint can be automatically satisfied if the curl form of the vorticity transport equations are discretized through the use of an appropriate staggered arrangement of the variables. Second-order accurate centered-space differences are used in the discretization, and suitable artificial dissipation terms are added to the difference equations in the manner of not destroying the basic divergence-free property of the resulting numerical scheme. The boundary vorticity is determined by the kinematic integral relationship between the vorticity and velocity distributions, with the vorticity constraint. Based on this method of determination, numerical techniques for efficient and accurate estimation of the boundary vorticity are presented. The surface pressure is also computed accurately using an integral representation for the pressure Poisson's equation. It appears that a solution of the Poisson's equation using the finite difference approximation could suffer from large discretization errors for flows over rapidly moving bodies. The validity of the present method is demonstrated by the application of the method to the problem of external flow past an impulsively starting NACA 0012 wing. Computational results are limited to low Reynolds-number flows in this study. They are investigated in various ways, compared with other numerical and experimental results available. Various important three-dimensional flow features are shown to be well simulated. By virtue of vorticity formulation, computation of dynamic flow about a maneuvering body is already in the scope of applicability of the present method. Also, computation of high Reynolds-number flows can be immediately carried out when an appropriate turbulence model is incorporated in the present solution scheme.
Dissert. Abstr.

N95-29118# University of Southern California, Los Angeles, CA.
AN EXTENSION OF THE CONTINUUM MODEL BY GRAD'S THIRTEEN MOMENT EQUATIONS FOR HYPERSONIC RAREFIED FLOWS Ph.D. Thesis
ERIC Y. WONG 1993
Avail: Issuing Activity (Univ. of Southern California, Doheny Library, Micrographics Dept., Los Angeles, CA 90089-0182)

Whereas it is well known that Grad's thirteen moment equations fail to yield solutions for normal shock structures at freestream Mach number larger than 1.65, it is recognized, however, that these equations may be used as an extension of the continuum model behind the shock. In this study, the 13-moment equations are applied to the flow between a strong bow shock and a solid surface under the thin shock layer formalism resulting in greatly simplified constitutive relations. Two dimensional hypersonic flows on the windward side of unaligned flat plates are studied to assess the accuracy of this 13-moment based shock-layer theory. In flows of large translational nonequilibrium, the 13-moment based predictions in heat transfer and skin friction are found to be in agreement with Direct Simulation Monte Carlo results. Comparisons of the parallel and perpendicular distribution functions also show reasonable agreements. Of interest is a correlation principle revealed by this study, which relates gas kinetic based results to corresponding Navier Stokes based solutions. A key to the derivation of the principle is the use of the Von Mises or Dorodnitsyn variables, which enable the reduction of the 13-moment based shock-layer equations to those of the Navier-Stokes based system. A critical test of the principle is conducted by examining the degree of successful correlations for the velocity and enthalpy profiles of a monatomic gas about the unaligned flat plates. Detailed comparisons with DSMC calculations support the viability of the principle. Dissert. Abstr.

N95-29121 Kansas Univ., Lawrence, KS.
NAVIER-STOKES SOLUTION OF WING WAKE STRUCTURE AND ITS PERTURBATION Ph.D. Thesis
TA-CHENG LEE 1993 134 p
Avail: Univ. Microfilms Order No. DA9425933

A 'flow embedding' method based on Navier-Stokes solutions is developed to calculate detailed wing wake structures. The method allows the calculation to be completed in two stages, first a global solution with a coarse grid and then the embedded solution in a small region with a dense grid. The boundary condition for the latter is obtained from the former. The main advantages of this two-staged scheme are: (1) it provides a very fine grid resolution in the region of interest to capture flow details; and (2) it calculates efficiently without demanding huge computer memory space. This embedded flow method, when comparing the numerical results with available experimental data in the near wake, is shown to produce a detailed and accurate wake structure for a delta wing. The computed results further downstream indicate that there are two concentrated vortices, one being the leading edge vortex, and the other being the trailing vortex, rotating opposite to each other. These two vortices stay strong and well organized from feeding of wake shear layers. Due to this effect, the total pressure and axial velocity of both vortices are increasing in the downstream direction. For the rectangular wing of aspect ratio 6, the calculated results are also compared with near-wake experimental data. Again, two vortices are identified, one being the conventional tip vortex and the other being the trailing vortex. The tip vortex is formed at the wing tip and moves outboard and upward; while the trailing vortex is formed downstream from the roll-up of shear layer and tends to move inboard and downward. The calculated total velocity in the core and the maximum tangential velocity around the trailing vortex core are shown to agree reasonably well with experimental data. The steady-state Navier-Stokes solution of the local wake flow region further serves as a base flow for wake attenuation investigations. An oscillatory disturbance is imposed at the trailing edge of the wing in an attempt to excite the instabilities of the wake flow. Results from the unsteady computations indicate that the current scheme can excite the wake flow with limited success. Dissert. Abstr.

N95-29129 ESDU International Ltd., London (England).
INCREMENTS IN AEROFOIL LIFT COEFFICIENT AT ZERO ANGLE OF ATTACK AND IN MAXIMUM LIFT COEFFICIENT DUE TO DEPLOYMENT OF A TRAILING-EDGE SPLIT FLAP, WITH OR WITHOUT A LEADING-EDGE HIGH-LIFT DEVICE, AT LOW SPEEDS
Dec. 1994 17 p
(ISSN 0141-397X)
(ESDU-94029; ISBN-0-85679-916-5) Avail: ESDU

ESDU 94029 presents an estimation method based on first approximations from the theory for a thin hinged plate modified using empirical correlation factors to account for the geometry of practical aerofoils and high-lift devices. To allow for the effects of chord extension, the flap chord ratio and lift coefficients are based on an aerofoil extended chord. The data for aerofoils with trailing-edge flaps deployed from which the methods were developed were extracted from wind-tunnel tests reported in the literature covering a wide range of practical geometries. Fewer data were available for aerofoils with both leading- and trailing-edge devices deployed. The methods apply to Reynolds numbers greater than a million and freestream Mach numbers less than 0.2. The predicted and test data for the lift coefficient increment at zero angle of attack correlated to within 10 per cent and for the increment in maximum lift coefficient to within 15 per cent. The use of the methods is illustrated by worked examples. To obtain results for an aerofoil with both leading-edge devices and split flaps deployed, ESDU 84026 is used in conjunction with this document and ESDU 94027. ESDU

N95-29243 Massachusetts Inst. of Tech., Cambridge, MA.
DYNAMIC STALL OF A NACA 0012 AIRFOIL IN LAMINAR FLOW Ph.D. Thesis
SASI K. DIGAVALLI 1994
Avail: Issuing Activity (MIT Libraries, Rm. 14-0551, Cambridge, MA 02139-4307)

The dynamic stall processes of a NACA 0012 airfoil oscillating sinusoidally in pitch and heave in laminar incompressible flow were investigated. The effects of changing the reduced frequency k from 0.6 to 1.2 and the pivot location x(0)/c from 1/4 to 3/4 were calculated. The nominal angle of incidence on the airfoil oscillated between 6 deg and 18 deg about a mean of 12 deg. The incompressible and inviscid external flow around the body was calculated using unsteady Bernoulli and a conformal transformation. The unsteady boundary layers were analyzed by C.C. Lin's asymptotic method applicable when the reduced frequency is 'large'. An unsteady separation condition, consistent with the Moore-Rott-Sears separation criterion, developed by A. Gioulekas as an extension of Stratford's separation condition for steady flows, was used to calculate the separation points of the boundary layers. The separated free shear layers were represented by discrete vortices. Each vortex was convected force-free (in the inertial frame) throughout the calculation by using the Biot-Savart law. The primary effect of moving the pivot towards the trailing edge is a delay in the onset of dynamic stall. The upstream movement of the separation point and the time of inception of the primary vortex are delayed. The slope of C(L)-alpha curve, the maximum velocity attained near the leading edge and the C(L(max)) decreased. The maximum penetration of the separation point towards the leading edge also decreased. The dwell time of the primary vortex near the leading edge is not altered significantly. Its maximum strength decreased while its average speed increased. Some of these effects of moving the pivot point and increasing k can qualitatively be forecast by analyzing the results from linear potential theory. Such an analysis leads to the definition of 'effective angle of incidence'. Dynamic stall characteristics of a heaving airfoil emulated some of the features of dynamic stall of a pitching airfoil with a rearward-pivot. Namely, upstream movement of the separation point and the inception of the primary vortex are delayed. The process of stall is less abrupt on a heaving airfoil than on a pitching airfoil with a forward pivot. The C(L(max)) and the strength of the primary vortex are both smaller. Some of these effects can also be deduced from an analysis of the simple linear potential theory. The effects of increasing the reduced frequency on the dynamic stalling of a heaving airfoil are similar to those on pitching airfoils. Dissert. Abstr.

N95-29316# CFD Research Corp., Huntsville, AL.
PRESSURE BASED HIGH ORDER TVD METHODOLOGY FOR DYNAMIC STALL CONTROL Final Report, 30 Sep. 1992 - 30 Sep. 1994
H. Q. YANG, Z. J. WANG, V. J. HARRAND, and A. J. PRZEKWAS
Nov. 1994 96 p
(Contract(s)/Grant(s): F49620-92-C-0070)
(AD-A290149; AFOSR-0020TR) Avail: CASI HC A05/MF A01

The objective was to study various dynamic stall control concepts using a code developed under Phase 1. The concepts studied were: vortex flaps, apex fence flaps, forebody strakes, spanwise blowing, leading edge blowing and suction, and forebody blowing and suction. DTIC

N95-29338*# Texas A&M Univ., College Station, TX.
A TWO ELEMENT LAMINAR FLOW AIRFOIL OPTIMIZED FOR CRUISE M.S. Thesis
GREGORY GLEN STEEN Aug. 1994 175 p
(Contract(s)/Grant(s): NAG1-1522)
(NASA-CR-198580; NAS 1.26:198580) Avail: CASI HC A08/MF A02

Numerical and experimental results are presented for a new two-element, fixed-geometry natural laminar flow airfoil optimized for cruise Reynolds numbers on the order of three million. The airfoil design consists of a primary element and an independent secondary element with a primary to secondary chord ratio of three to one. The airfoil was designed to improve the cruise lift-to-drag ratio while maintaining an appropriate landing capability when compared to conventional airfoils. The airfoil was numerically developed utilizing the NASA Langley Multi-Component Airfoil Analysis computer code running on a personal computer. Numerical results show a nearly 11.75 percent decrease in overall wing drag with no increase in stall speed at sailplane cruise conditions when compared to a wing based on an efficient single element airfoil. Section surface pressure, wake survey, transition location, and flow visualization results were obtained in the Texas A&M University Low Speed Wind Tunnel. Comparisons between the numerical and experimental data, the effects of the relative position and angle of the two elements, and Reynolds number variations from 8 x 10(exp 5) to 3 x 10(exp 6) for the optimum geometry case are presented. Author

N95-29402*# Modern Technologies Corp., Middleburg Heights, OH. Cleveland Office.

THE DECAY OF LONGITUDINAL VORTICES SHED FROM AIRFOIL VORTEX GENERATORS Final Contractor Report

BRUCE J. WENDT, BRUCE A. REICHERT (Kansas State Univ., Manhattan, KS.), and JEFFRY D. FOSTER (Iowa State Univ. of Science and Technology, Ames, IA.) Jun. 1995 13 p Presented at the 13th Applied Aerodynamics Conference, San Diego, CA, 19-22 Jun. 1995; sponsored by AIAA

(Contract(s)/Grant(s): NAS3-27377; RTOP 505-62-52)

(NASA-CR-198356; E-9730; NAS 1.26:198356; AIAA PAPER 95-1797) Avail: CASI HC A03/MF A01

An experimental study is conducted to examine the crossplane structure and streamwise decay of vortices shed from airfoil-type vortex generators. The vortex generators are set in a counter-rotating array spanning the full circumference of a straight pipe. The span of the vortex generators above the duct surface, h, is approximately equal to the local turbulent boundary layer thickness, delta. Measurement of three-component mean flow velocity in downstream crossplanes are used to characterize the structure of the shed vortices. Measurements in adjacent crossplanes (closely spaced along the streamwise coordinate) characterize the interaction and decay of the embedded vortices. A model constructed by the superposition of Oseen vortices is compared to the data for one test case. Author

N95-29428# Naval Postgraduate School, Monterey, CA. Dept. of Aeronautics and Astronautics.

COMPRESSIBILITY EFFECTS ON AND CONTROL OF DYNAMIC STALL OF OSCILLATING AIRFOIL Final Report, 14 Mar. 1990 - 30 Jun. 1994

M. S. CHANDRASEKHARA 23 Dec. 1994 52 p

(Contract(s)/Grant(s): ARO-MIPR-103-94)

(AD-A291804; ARO-27894.27-EG) Avail: CASI HC A04/MF A01

A three year effort to study the 'Compressibility Effects on the Control of Dynamic Stall of Oscillating Airfoils' was funded by ARO in 1990. A fourth year extension was granted for the project. As part of this research, a new real-time interferometry system known as Point Diffraction Interferometry (PDI) was developed. Several new and exciting details of the dynamic stall flow over an oscillating airfoil such as formation of multiple shocks were captured. The study also addressed the role of transition in influencing the dynamic stall process. A concurrent computational study was carried out to investigate the role of transition. Additionally, LDV measurements of the dynamic stall flow were obtained which support the PDI observations. A high speed PDI 'movie' imaging system was designed to capture events of dynamic stall during a single pitch-up motion of the airfoil. This report describes the significant results obtained from the four year study of dynamic stall over an oscillating airfoil. DTIC

N95-29500# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

AN EXPERIMENTAL INVESTIGATION OF THE TIME-DEPENDENT SEPARATION OF TANGENT BODIES IN SUPERSONIC FLOW Final Report Ph.D. Thesis

NEAL ANTHONY MOSBARGER 1 Dec. 1994 318 p

(AD-A290720; AFIT/DS/AA/94-7) Avail: CASI HC A14/MF A03

An experimental, time-dependent separation of tangent bodies was performed in a supersonic wind tunnel (Mach 1.5 and 1.9) to investigate the significance of transient effects and the suitability of using steady-state assumptions to predict a dynamic separation event. The model configurations consisted of two bodies placed in a near tangent position. A stationary body, plate or ogive, was instrumented to obtain dynamic surface pressures, while a second body, a wedge attached to an air cylinder, was plunged in a constrained motion away from and towards the stationary model. Three-dimensional flow expansion around the edge of the wedge reduced the strength of the shock waves and created a region of low pressure, near freestream static, on body surfaces between the incident and reflection shock waves. The dynamic motion of the wedge did not significantly affect the shock wave development between the bodies, and steady-state corrections that accounted for the motion-induced wedge angle were appropriate for predicting the time-dependent surface pressures induced by the incident shock wave. DTIC

N95-29640# Tokyo Univ. (Japan). Inst. of Space and Astronautical Science.

TRANSONIC, SUPERSONIC AND HYPERSONIC WIND-TUNNEL TESTS ON AERODYNAMIC CHARACTERISTICS OF REENTRY BODY WITH BLUNTED CONE CONFIGURATION

KOJIRO SUZUKI and TAKASHI ABE Mar. 1995 28 p

(ISAS-658) Avail: CASI HC A03/MF A01

The aerodynamic characteristics of the early version of the 'EXPRESS' reentry capsule, having a blunted cone configuration with flat bottom, are investigated experimentally over a wide range of the Mach number from 0.6 to 7.1 by using the transonic, supersonic and hypersonic wind tunnels. The continuity of the experimental data with respect to the Mach number is examined especially at the Mach numbers where the experimental facility is changed from the transonic wind tunnel to the supersonic wind tunnel and from the supersonic wind tunnel to the hypersonic wind tunnel. The experimental data in the supersonic and hypersonic regime show the tendency that when the Mach number becomes large, the aerodynamic characteristics become independent of the Mach number. It is clarified that in the transonic regime the aerodynamic center of the capsule moves forward and the static stability of the vehicle on the pitch plane is significantly reduced. In order to overcome such reduction in the static stability of the vehicle, it is necessary to deploy the parachute behind the capsule by the time when the flight Mach number decreases to the transonic regime and the static stability around the center-of-gravity vanishes. The critical Mach number for the parachute deployment is determined for various center-of-gravity locations. When the center-of-gravity of the capsule is located around the center of the body, the parachute must be deployed at supersonic speed. The effects of the nose shape and the bottom configuration on the aerodynamic characteristics of the capsule are experimentally investigated The validity of the Newtonian flow analysis in prediction of the aerodynamic characteristics of the capsule is assessed by comparisons with the experimental data. Author

N95-29771 Georgia Inst. of Tech., Atlanta, GA.

UNSTEADY PRESSURE AND INFLOW VELOCITY ON A PITCHING ROTOR BLADE IN HOVER Ph.D. Thesis

MIHIR KUMAR LAL 1993 221 p

Avail: Univ. Microfilms Order No. DA9415649

This dissertation seeks to describe and analyze the measurements of inflow velocity and chordwise distributions of unsteady pressure at three radial locations on a stiff two-bladed teetering helicopter rotor in hover, with the blades executing simple harmonic pitch oscillations about the quarter-chord pitch axis. The objective was to develop viable measurement techniques for determination of unsteady pressure and inflow velocity in the near field of a rotor blade for axial flow, with simple harmonic oscillation in pitch about finite mean values. These techniques enabled measurement of unsteady pressure and inflow velocity for a range of inflow conditions encompassed by the investigation. Two means of changing the mean inflow independent of reduced frequency have been employed, first by an appropriate combination of rotor speed and forcing frequency, and second by changing the mean pitch angle. The phase effects, reduced frequency effects, and the 3-dimensional tip effects on the lifting perturbation pressure have also been demonstrated. The unsteady pressures are correlated with Theodorsen's and Loewy's 2-dimensional incompressible unsteady aerodynamic theories and with Kaladi's pulsating doublet distribution method. The level of agreement between these analytical methods and the experiment has been assessed and guidelines have been provided for their use in order to obtain best possible results under given operating conditions and radial locations. Inflow velocity measured using a Laser Doppler Velocimeter is correlated with Peters' theory. The inflow velocity agrees very well with Peters' theory under steady as well as dynamic pitch. The inflow velocity under dynamic pitch shows velocity perturbation and dependence on the phase of excitation. Spectral analysis shows multiple harmonics of forcing frequency. Hysteresis is observed in inflow velocity which decays towards the tip. Dissert. Abstr.

N95-29788 Iowa State Univ. of Science and Technology, Ames, IA.
COMPUTATION OF THE INTEGRATED AERODYNAMIC AND PROPULSIVE FLOWFIELDS OF A GENERIC HYPERSONIC SPACE PLANE Ph.D. Thesis
GANESH WADAWADIGI 1993 85 p
Avail: Univ. Microfilms Order No. DA9414032

A new upwind, parabolized Navier-Stokes (PNS) code has been developed to compute two- and three-dimensional (3D) chemically reacting, turbulent flows with hydrogen-air chemistry. The code is a modification of the 3D upwind PNS (UPS) airflow code. The code solves the PNS equations using a finite-volume upwind, TVD (Total Variation Diminishing) method based on Roe's approximate Riemann solver that has been modified to account for non equilibrium effects. The fluid medium is assumed to be a chemically reacting mixture of thermally perfect (but calorically imperfect) gases in thermal equilibrium. Two turbulence models have been incorporated into the code including an algebraic model, that has the ability to account for internal flows with multiple walls, and a two-equation kappa-epsilon turbulence model. For the two-equation turbulence model option, the code solves the turbulence transport equations in an uncoupled manner from the fluids equations. With these enhancements, the UPS code is now capable of computing the chemically reacting flow in scramjet (supersonic combustion ramjet) engines. Various component test cases have been used to validate the code. The computed results are in good agreement with the available numerical and analytical solutions and experimental data. Finally, the full capabilities of the new code have been demonstrated with a 3D tip-to-tail numerical calculation of the integrated aerodynamic and propulsive flowfields of a generic hypersonic space plane. Two test cases, one with power-off and one with power-on, were considered to study the flow structure around such a configuration. Both tip-to-tail cases were successfully computed in this study. Dissert. Abstr.

N95-29853# Naval Surface Warfare Center, Dahlgren, VA.
THE 1995 VERSION OF THE NSWC AEROPREDICTION CODE. PART 1: SUMMARY OF NEW THEORETICAL METHODOLOGY Final Report
FRANK G. MORRE, ROY M. MCINVILLE, and TOM HYMER Feb. 1995 111 p
(AD-A291518; NSWCDD/TR-94/379) Avail: CASI HC A06/MF A02

The NSWC Aeroprediction Code has been extended to angles of attack (AOA) greater than 30 deg. To accomplish this, several data bases were used to approximate the nonlinearities in individual missile component aerodynamics. Theoretical aerodynamic methods are used at small AOA. The new semiempirical model was applied to several configurations and the empirical constants adjusted to eliminate some of the errors associated with wind tunnel measurements of individual missile component loads. The new version of the code (AP95) was then applied to several other missile configurations and estimates compared to data and other aerodynamic code calculations. Comparisons were made for Mach numbers 0.1 to 10.0 and AOA of 0 to 90 deg (not all data were available on any single configuration). In general, average accuracy levels of + or - 10 percent could be obtained for axial and normal force coefficient and + or - 4 percent of body length for center of pressure, using the AP95. An exception to this was at AOA above 30 deg and at high supersonic Mach numbers, where nonlinearities caused by internal shock interactions were not accounted for. While these accuracy levels are very encouraging for a semiempirical code, improvements on the AP95 methodology could be made by additional missile-component wind-tunnel data at high AOA. DTIC

N95-29898 ESDU International Ltd., London (England).
INCREMENTS IN AEROFOIL LIFT COEFFICIENT AT ZERO ANGLE OF ATTACK AND IN MAXIMUM LIFT COEFFICIENT DUE TO DEPLOYMENT OF VARIOUS LEADING-EDGE HIGH-LIFT DEVICES AT LOW SPEEDS
Dec. 1994 27 p
(ISSN 0141-397X)
(ESDU-94027; ISBN-0-85678-914-9) Avail: ESDU

ESDU 94027 presents an estimation method based on first approximations from the theory for a thin hinged plate modified using empirical correlation factors to account for the geometry of practical aerofoils and high-lift devices. It applies to plain flaps, drooped leading edges, slats (including sealed slats) and Kruger flaps (including vented Krugers). To allow for the effects of chord extension, the flap chord ratio and lift coefficients are based on an aerofoil extended chord. The data from which the methods were developed were extracted from wind-tunnel tests reported in the literature covering a wide range of practical geometries. However, the methods for Kruger flaps apply only to those cases in which the flap leading-edge radius is the same as that of the basic aerofoil. The methods apply to Reynolds numbers greater than a million and freestream Mach numbers less than 0.2. The predicted and test data for the lift coefficient decrement at zero angle of attack are correlated to within 0.07 and the increment in maximum lift coefficient to within 0.1. The use of the methods is illustrated by worked examples. To obtain results for an aerofoil with both leading- and trailing-edge devices deployed, ESDU 84026 is used in conjunction with results from this document and the appropriate document of ESDU 94027 to 94031 for the contribution of trailing-edge devices. ESDU

N95-29899 ESDU International Ltd., London (England).
INTRODUCTION TO THE ESTIMATION OF THE LIFT COEFFICIENTS AT ZERO ANGLE OF ATTACK AND AT MAXIMUM LIFT FOR AEROFOILS WITH HIGH-LIFT DEVICES AT LOW SPEEDS
Dec. 1994 12 p
(ISSN 0141-397X)
(ESDU-94026; ISBN-0-85679-913-0) Avail: ESDU

ESDU 94026 discusses the behavior of the lift-curve of an aerofoil depending on its thickness/chord ratio, and the effects on that behavior of the deployment of high-lift devices. It provides an introduction to and a link between ESDU 84026 which predicts lift at zero incidence and maximum lift for the basic aerofoil with high-lift devices undeployed and the series, ESDU 94026 to 94031, which deals with the incremental effects of deployment of the various types of leading-edge and trailing-edge devices. The method of incorporating the incremental effects is explained and illustrated with a worked example, and the applicability and accuracy of the method is discussed. ESDU

N95-29965 Air Force Inst. of Tech., Wright-Patterson AFB, OH.
AN AERODYNAMIC AND STATIC-STABILITY ANALYSIS OF THE HYPERSONIC APPLIED RESEARCH TECHNOLOGY (HART) MISSILE Ph.D. Thesis
KENNETH JOHN MORAN 1994 227 p
(DA9426923) Avail: Issuing Activity (WL/MTPN, Wright-Patterson AFB, OH 45433-6533)

The flow about the complete Hypersonic Applied Research

Technology (HART) missile is simulated for inviscid, laminar, and turbulent conditions and Mach numbers from 2 to 6. An explicit, second-order-accurate, flux-difference-splitting, algorithm is implemented and employed to solve the Navier-Stokes equations. The formulation models turbulence with the zero-equation, Baldwin-Lomax turbulence model, accounting for pressure-gradient and compressibility effects. The equations are solved using a finite-volume methodology. In the first part of the study, numerical experiments are performed using an infinitely thin-fin approximation. The aerodynamic and static stability characteristics are investigated to determine if conventional supersonic missile configurations can be flown at Mach numbers higher than 5. The effects of nosetip blunting and boundary-layer condition are demonstrated. In addition, many unresolved issues from experimental testing of the HART missile are addressed. In the second part of the study, the effects of fin thickness and cross section are explored. A comparison is made between thin-fin results and thick-fin results to assess the impact on missile stability. The structure of the flow near the fins is significantly affected by the turbulent transport of momentum in regions of blocked cross flow. Turbulence and the blockage phenomenon cause bleeding around the fin leading edges. Ultimately, this results in lower fin effectiveness and reduced static stability. In addition, the strength and extent of the flow structures that develop in the blocked regions appear to be enhanced by fin thickness. The aerodynamic characteristics of the HART missile are predicted at Mach numbers beyond the experimental free-flight testing capabilities. The current predictions indicate that the pitching-moment coefficient decreases with increasing Mach number much less than previous numerical computations. The present results also suggest that the clipped-delta-fin configuration is stable beyond Mach 7. Dissert. Abstr.

N95-29972# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
COMPUTATIONAL ALGORITHMS FOR AERODYNAMIC ANALYSIS AND DESIGN Annual Report, 1 Oct. 1993 - 30 Sep. 1994
ANTONY JAMESON, JAMES REUTHER, and LUIGI MARTINELLI Sep. 1994 13 p
(Contract(s)/Grant(s): AF-AFOSR-0391-91)
(AD-A291084; AFOSR-95-0082TR) Avail: CASI HC A03/MF A01

The goal of our research under AFOSR sponsorship is to develop mathematical procedures which can be used to arrive at optimum, or near optimum, aerodynamic shapes by merging techniques from computational fluid dynamics and control theory. With this in mind we have continued to work in two main topics: Development of high resolution shock capturing schemes with low numerical diffusion. Since last year the symmetric limited positive (SLIP) and upstream limited positive (USLIP) schemes have been improved by the introduction of a new flux limiter which guarantees positivity while maintaining good accuracy in smooth flow regions. A comprehensive theory has also been developed for design of numerical fluxes which guarantee stationary discrete shocks with a single interior point. Aerodynamic shape optimization by boundary control progress in aerodynamic shape optimization has been realized on two fronts. First the method has been successfully implemented for two-dimensional lifting potential flows using a general finite volume scheme with numerically generated grids. Secondly, the method has been successfully implemented for three-dimensional wing design using the Euler equations. DTIC

N95-30091*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
USE OF THE PARC CODE TO ESTIMATE THE OFF-DESIGN TRANSONIC PERFORMANCE OF AN OVER/UNDER TURBORAMJET NOZZLE
DAVID W. LAM Jul. 1995 18 p Presented at the 31st Joint Propulsion Conference and Exhibit, San Diego, CA, 10-12 Jul 1995; sponsored by AIAA, ASME, SAE, and ASEE
(Contract(s)/Grant(s): RTOP 505-70-62)
(NASA-TM-106924; E-9638; NAS 1.15:106924; AIAA PAPER 95-2616) Avail: CASI HC A03/MF A01

The transonic performance of a dual-throat, single-expansion-ramp nozzle (SERN) was investigated with a PARC computational fluid dynamics (CFD) code, an external flow Navier-Stokes solver. The nozzle configuration was from a conceptual Mach 5 cruise aircraft powered by four air-breathing turboramjets. Initial test cases used the two-dimensional version of PARC in Euler mode to investigate the effect of geometric variation on transonic performance. Additional cases used the two-dimensional version in viscous mode and the three-dimensional version in both Euler and viscous modes. Results of the analysis indicate low nozzle performance and a highly three-dimensional nozzle flow at transonic conditions. In another comparative study using the PARC code, a single-throat SERN configuration for which experimental data were available at transonic conditions was used to validate the results of the over/under turboramjet nozzle. Author

N95-30235 Ohio State Univ., Columbus, OH.
A NUMERICAL STUDY OF THE SMALL SCALE WING-BODY JUNCTION PROBLEM Ph.D. Thesis
EUN YOUNG LEE 1994 152 p
Avail: Univ. Microfilms Order No. DA9420980

Inspired by asymptotic theory, a solution method has been developed for the calculation of the wing-body junction problem. Some flaws in Smith and Gajjar's theory have been corrected for the linearized solutions. As a part of solution procedure, effective hump shapes are generated using a transformation technique applied to the pressure-displacement relationship. Numerical solutions of the non-linear triple-deck equations of boundary-layer flow past a smooth, three-dimensional, surface-mounted wing are presented. The results obtained from finite-difference nonlinear solutions are confirmed by linearized fast Fourier transform solutions. Dissert. Abstr.

N95-30253*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
GRID RESOLUTION AND TURBULENT INFLOW BOUNDARY CONDITION RECOMMENDATIONS FOR NPARC CALCULATIONS
NICHOLAS J. GEORGIADIS, JULIANNE C. DUDEK, and THOMAS P. TIERNEY (Massachusetts Inst. of Tech., Cambridge, MA.) Jul. 1995 18 p Presented at the 31st Joint Propulsion Conference and Exhibit, San Diego, CA, 10-12 Jul. 1995; sponsored by AIAA; ASME; SAE; and ASEE
(Contract(s)/Grant(s): RTOP 537-02-23)
(NASA-TM-106959; E-9711; NAS 1.15:106959; AIAA PAPER 95-2613) Avail: CASI HC A03/MF A01

The effects of grid resolution and specification of turbulent inflow boundary conditions were examined using the NPARC code with the Baldwin-Lomax and Chien k-e turbulence models. Three benchmark turbulent test cases were calculated: two were wall bounded flows and the third was a compressible mixing layer. The wall bounded flows were essentially insensitive to axial grid density; however, the location of the first point off the wall had a substantial effect on flow solutions. It was determined that the first point off the wall must be in the laminar sublayer (y+ less than or equal to 5) for the entire boundary layer. For the compressible mixing layer cases, the axial grid density affected the capturing of oblique shock waves in the mixing region, but the overall mixing rate was not strongly dependent on grid resolution. In specifying the inflow turbulent boundary conditions, it was very important to match the boundary layer and momentum thicknesses of the two flows entering the mixing region; calculations obtained with smaller or no boundary layers resulted in substantially reduced mixing. The solutions were relatively insensitive to freestream turbulence level. Author

N95-30294 Arizona State Univ., Tempe, AZ.
GROWTH AND DEVELOPMENT OF ROUGHNESS-INDUCED STATIONARY CROSSFLOW VORTICES Ph.D. Thesis
RONALD HENRY RADEZTSKY, JR. 1994 480 p
Avail: Univ. Microfilms Order No. DA9422060

Stability experiments are conducted in the Arizona State University Unsteady Wind Tunnel with a 45 deg swept airfoil model. The pressure field is designed so that crossflow and Tollmien-Schlichting instabilities are weakly amplified. The surface of the airfoil is hand polished to a 0.25 micron finish. Under these conditions, natural stationary crossflow amplitudes are not measurable. This provides an ideal environment for measuring roughness-induced stationary crossflow. Spanwise arrays of 70-150 micron roughness elements are introduced near the attachment line. These elements induce clearly defined stationary crossflow vortices downstream. Detailed hot-wire measurements are taken to document the growth and development of these vortices. Roughness spacing and Reynolds number are varied in order to examine the behavior of all amplified wavelengths. The measurements clearly show that traditional linear stability theory does not accurately predict the growth rates of stationary crossflow under these conditions. Dissert. Abstr.

N95-30349# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany). Inst. of Fluid Mechanics.
NUMERICAL SIMULATION AND ANALYSIS OF THE HYPERSONIC TURBULENT FLOW PAST A BLUNT-FIN/ RAMP CONFIGURATION Ph.D. Thesis - Rheinisch-Westfaelische Technische Hochschule Aachen [NUMERISCHE SIMULATION UND ANALYSE DER TURBULENTEN HYPERSCHALLSTROEMUNG UM EINEN STUMPFEN FIN MIT RAMPE]
THOMAS GERHOLD Cologne 1994 159 p In GERMAN
(ISSN 0939-2963)
(DLR-FB-94-19) Avail: CASI HC A08/MF A02

The turbulent hypersonic flow past a blunt-tin/ramp configuration is investigated numerically. The compressible mass-weighted Reynolds-averaged Navier-Stokes equations are solved by an implicit finite-difference algorithm with upwind-discretization and TVD property. Perfect gas is assumed. For the closure of the equations the algebraic turbulence model according to Baldwin & Lomax, as well as different versions of a two-equation kappa-epsilon-model according to Jones & Launder are used. One version of this model accounts for compressibility effects on the turbulence. The influence of the turbulence models on the flow-field simulation is investigated, the grid influence is discussed and the topology of the flow field is depicted by using the results obtained. For validation purposes the results are compared with new experimental data. Finally, the extrapolation to flight of the results is discussed. Author

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A95-87248
CONCORDE: SILVER JUBILEE MACH 2 MARKS 25 YEARS
PAUL RELMAN Air International (ISSN 0306-5634) vol. 46, no. 3 March 1994 p. 120-124
(HTN-95-42618) Copyright

To mark the 25th aniversary of the first Concorde flight, the background to this famous, if commercially unsuccessful, pioneer of supersonic travel is considered, and the future of the concept of air travel beyond the sound barrier is evaluated. Author (Herner)

A95-88964* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LIGHTNING PROTECTION TECHNOLOGY FOR SMALL GENERAL AVIATION COMPOSITE MATERIAL AIRCRAFT
J. A. PLUMER Lightning Technologies, Inc., US, T. E. SETZER Stoddard-Hamilton Aircraft, Inc., US, and S. SIDDIQI Analytical Services & Materials, Inc., US (ISSN 0148-7191) 1993 6 p. SAE General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, KS, May 18-20, 1993
(Contract(s)/Grant(s): NAS1-19316)
(SAE PAPER 931241; HTN-95-20925) Copyright

An on going NASA (Small Business Innovative Research) SBIR Phase II design and development program will produce the first lightning protected, fiberglass, General Aviation aircraft that is available as a kit. The results obtained so far in development testing of typical components of the aircraft kit, such as the wing and fuselage panels indicate that the lightning protection design methodology and materials chosen are capable of protecting such small composite airframes from lightning puncture and structural damage associated with severe threat lightning strikes. The primary objective of the program has been to develop a lightening protection design for full scale test airframe and verify its adequacy with full scale laboratory testing, thus enabling production and sale of owner-built, lightning-protected, Stoddard-Hamilton Aircraft, Inc. Glasair II airplanes. A second objective has been to provide lightning protection design guidelines for the General Aviation industry, and to enable these airplanes to meet lightening protection requirements for certification of small airplanes. This paper describes the protection design approaches and development testing results obtained thus far in the program, together with design methodology which can achieve the design goals listed above. The presentation of this paper will also include results of some of the full scale verification tests, which will have been completed by the time of this conference.
Author (revised by Herner)

A95-89220
FAA'S AGING COMMUTER AIRPLANE PROGRAM
BOBBY W. SEXTON (ISSN 0148-7191) 20 May 1993 10 p. SAE, General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, Kansas, May 18-20, 1993
(SAE PAPER 931248; HTN-95-B0276) Copyright

This paper describes FAA's aging commuter airplane program and provides a snap-shot of the existing commuter fleet. It describes the development of the program and compares the commuter program with FAA's program to address aging large transport airplanes. It lists recent congressional actions addressing aging airplanes, summarizes the regulatory history of structural substantiation methods for commuter sized airplanes, identifies needed regulatory and policy changes, and provides insight into the future direction of the program. Author (revised by Herner)

A95-90867
TEST AND EVALUATION CREW RESOURCE MANAGEMENT
RODRIGO J. HUETE National Test Pilot School, Mojave, CA, US and JOHN J. NANCE USAFR, US *In* Report to the aerospace profession; SETP Symposium, 37th, Beverly Hills, CA, USA, September 1993. A95-90866 Lancaster, Calif. Society of Experimental Test Pilots
(ISSN 0742-3705) September 1993 p. 4-16 Copyright

Crew coordination and teamwork has been, to varying degrees, institutionalized in both military and airline training. The concept of Crew Resource Management (CRM) has been at least acknowledged if not incorporated in aviation training programs; CRM is, therefore, not a new concept anymore. What is new, and still evolving, is the projection of CRM principles outside of what has been considered the core of aviation crews, the cockpit crew. It has not been until recently that the focus has shifted to include a team concept. In fact, the acronym CRM has changed from Cockpit Resource Management to Crew Resource Management in order to incorporate a larger part of the humans involved in flight operations; the carbon-based units. The airline industry, although not initially in favor of CRM training, has begun to realize the benefits of such training. Several examples can be cited today where CRM training has been identified as a main reason for saves in airline 'close calls' or reducing the effects of mishaps. Nevertheless, statistics show, even today, that approximately 67 percent of aviation mishaps are caused by human performance errors (military and civilian). The flight test community has not escaped these statistics. The case studies presented in this paper are graphic examples of the potential for human performance errors in flight test operations.

Author (Herner)

A95-91450

INADEQUACY OF VISUAL ALARMS IN HELICOPTER AIR MEDICAL TRANSPORT

ROBERT E. FROMM, JR. The Methodist Hospital and Baylor College of Medicine, Houston, TX, US, EDWINA CAMPBELL The Methodist Hospital and Baylor College of Medicine, Houston, TX, US, and PATRICIA SCHLIETER The Methodist Hospital and Baylor College of Medicine, Houston, TX, US Aviation, Space, and Environmental Medicine (ISSN 0095-6562) vol. 66, no. 8 August 1995 p. 784-786
(HTN-95-01218) Copyright

Air medical programs use medical equipment primarily designed for hospital and/or ground transport settings. Many of these medical devices are equipped with auditory alarms of malfunction or deteriorating clinical status. The high ambient noise requires visual scanning of medical devices to detect alarm conditions in the helicopter cabin. The purpose of this study was to evaluate the adequacy of visual scanning for alarm conditions in the helicopter air medical environment. The helicopter transport program used in this study is staffed with two medical crewmembers. Flight nurse response time (RT) to a visual alarm was assessed during 25 air medical patient flights. RT was measured using a battery powered dual timer device with a red LED visual alarm placed in a fixed position among the medical instruments. The device was activated at a random time point unknown to the medical crew during each patient flight. RT was defined as the elapsed time from activation of the alarm until it was physically switched off by the flight nurse. RT was suprisingly lengthy for the study population with a mean RT of 81.2 +/- 78.4 s (95% CI 48.8-113.5 s). The variability of RT was also suprisingly ranging from 3 s to greater than 5 min. RT to visual alarms in the air medical environment is lengthy and quite variable. Recognition of malfunction of medical equipment of early signs of clinical instability prior to clinical deterioration cannot be assured by visual scanning for alarm conditions. Alternative alarming systems should be considered and investigated for air medical transport.

Author (Herner)

A95-91701

AGEING AIRCRAFT AFTER ALOHA

P. J. BASHFORD 1991 7 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 11: Ageing Aircraft & Survivability)
(CONGRESS PAPER C428-11-188; HTN-95-21132) Copyright

Following the near loss of an ALOHA airlines aircraft due to explosive decompression, in April 1988, industry, constructors and authorities have been working together in an attempt to enhance confidence in the maintenance of continued structural safety of older aircraft. This paper decribes the status of that work today and activities planned for the immediate future. Author (Herner)

A95-91702

EXPLOSIVE SABOTAGE: THE POTENTIAL EFFECTS OF EXPLOSIVE CHARGES ON AIRCRAFT

C. PROTHEROE Air Accidents Investgation Branch, UK 1991 7 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 11: Ageing Aircraft & Survivability)
(CONGRESS PAPER C428-11-034; HTN-95-21133) Copyright

Once it had been confirmed that the loss of the Boeing 747 of Pan Am flight 103 was caused primarily by explosive sabotage, a decision was taken by the UK Air Accidents Invesigation Branch to extend the investigation by analyzing the wreckage for evidence of the explosive break-up mechanisms. It was hoped that the information thus obtained would stimulate discussion and provide a basis for further research aimed at improving the resistance of aircraft to explosive sabotage. The investigation of the explosive break-up of Pan Am flight 103 over Lockerbie is summarized and explosive damage mechanisms which contributed to the disintegration are outlined. These mechanisms are applicable to most large civil aircraft. Author (revised by Herner)

A95-91717

RAF EJECTIONS - HISTORICAL PERSPECTIVES AND FUTURE REQUIREMENTS

D. J. ANTON Institute of Aviation Medicine, RAF, UK 1991 7 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 18: Crew Escape Systems)
(CONGRESS PAPER C428-18-168; HTN-95-21148) Copyright

The decision to develop the European Fighter Aircraft led to a review of the Royal Air Force ejections and ejection seat performance characteristics. The final specification of the ejection seat for this aircraft was derived from accident experience and from analysis of ejection test data from previous marks of ejection seat. This paper discusses some of the major historical injury problems including impairment of consiousness on ejection, the rationale for improvements in ejection seat stability, and measures taken to improve ejection seat headbox impact attenuation. Author (Herner)

A95-91718

COMPUTER SIMULATION OF EJECTION SEAT MOTION

P. R. DOWNS 1991 2 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 18: Crew Escape Systems)
(CONGRESS PAPER C428-18-169; HTN-95-21149) Copyright

The development of the ejection seat over many years has resulted in a reliable means of escape for aircrew in a wide range of emergency situations. Generally new seat developments are tested and evaluated using a variety of test rigs, aircraft and rocket propelled sled trials to cover the escape envelope conditions. Such trials are inevitably expensive as well as time consuming and the decision was therefore taken several years ago to undertake the development of a computer simulation of ejection seat motion as being a likely way of reducing the costs of research and developmennt work by reducing the number of tests required. This paper describes the development and subsequent use of a six degree of freedom computer simulation, which is used to predict the trajectory and attitude of an ejected package. Author (revised by Herner)

A95-91846

EXPLANATORY FACTORS FOR THE GEOGRAPHIC DISTRIBUTION OF U.S. CIVIL AVIATION MORTALITY

TIMOTHY J. UNGS U.S. Coast Guard Headquarters, Washington, DC, US Aviation, Space, and Environmental Medicine (ISSN 0095-6562) vol. 66, no. 6 June 1995 p. 522-527
(HTN-95-92908) Copyright

State-specific aviation-related mortality rates differ substantially between various geographical regions of the United States. The purpose of this study was to ascertain important explanatory factors that account for the geographical distribution of mortality. National Center for Health Statistics sources were used to calculate state-specific, age-adjusted mortality rates. Fatalities studied were those attributed to select civil aviation-related causes that occurred from 1979-89. State-specific information on a variety of selected variables was obtained from census, commerce, and Federal Aviation Administration (FAA) sources. Multiple linear regression techniques were used to assess the relationship between selected variables and state-specific mortality rates. There were 13,048 deaths for a U.S. 11-year mean mortality rate of 4.9 deaths/1,000,000 general population. Mountainous states of the western U.S. had the highest 11-year mean mortality rates (range 8.6-79.6 deaths/1,000,000). Mid-Atlantic states had the lowest rates (range 1.6-2.9 deaths/1,000,000). Regression analysis identified pilot density (number of pilots per 1,000,000 general population), top elevation (highest point of land within state boundaries), and flight intensity (number of general aviation flight hours flown per pilot) as important factors in explaining 92% of state mortality differences. Highest aviation-related mortality rates are found in states with expanses of mountainous terrain, and relatively high pilot densities and flight activity levels. Author (Herner)

A95-91913
DEATHS AND INJURIES AS A RESULT OF LIGHTNING STRIKES TO AIRCRAFT
MICHAEL CHERINGTON St. Anthony Hospital Central, Denver, CO, US and KARLA MATHYS St. Anthony Hospital Central, Denver, CO, US Aviation, Space, and Environmental Medicine (ISSN 0095-6562) vol. 66, no. 7 July 1995 p. 687-689
(HTN-95-12213) Copyright

Aircraft are at risk of being struck by lightning or triggering lightning as they fly through clouds. Commercial and private airplanes have been struck, with resultant deaths and injuries to passengers and crew. We were interested in learning how large a problem existed to the American public from lightning strikes to airplanes. We analyzed data from the National Transportation Safety Board (NTSB) on lightning-related accidents in the United States from 1963-89. NTSB recorded 40 lightning-related aircraft accidents. There were 10 commercial airplane accidents reported, 4 of which were associated with 260 fatalities and 28 serious injuries. There were 30 private aircraft accidents that accounted for 30 fatalities and 46 serious injuries. While lightning remains a potential risk to aircraft passengers and crew, modern airplanes are better equipped to lessen the dangers of accidents due to lightning. Author (Herner)

N95-28811# Dayton Univ., OH. Research Inst.
AN ANALYSIS OF B-1B EXTERIOR JET BLAST WINDSHIELD ANTI-ICING PERFORMANCE USING PRE-COOLED COMPRESSOR BLEED AIR Interim Report, for 1 Mar. - 1 May 1994
D. S. EMMER and M. P. BOUCHARD Jul. 1994 30 p
(Contract(s)/Grant(s): F33615-92-C-3400)
(AD-A292522; UDR-TR-94-94; WL-TR-94-3129) Avail: CASI HC A03/MF A01

This work presents the results of an analytical study designed to evaluate whether the B-1B hot-air windshield deicing/anti-icing system, operating independently from the embedded electrical resistance system, was capable of adequately meeting deicing and anti-icing requirements. Two icing scenarios were considered in loiter, landing, and ground/taxi modes of operation. The results indicate that in a loiter and landing mode, the system capability ranges from marginal to adequate. Additional work is needed to expand the applicability of the analysis mode to ground/taxi conditions. DTIC

N95-29057# Army Aeromedical Research Lab., Fort Rucker, AL.
BIODYNAMIC SIMULATION OF PILOT INTERACTION WITH A HELICOPTER MULTIAIRBAG RESTRAINT SYSTEM
GREGORY STRAWN and NABIH M. ALEM Oct. 1994 37 p
(AD-A290196; USAARL-95-3) Avail: CASI HC A03/MF A01

The introduction of airbags into the helicopter cockpit has raised the issue of acceptable limits on the weights of helmet-supported devices which can be tolerated safely by the aviator. It is hypothesized that, if the acceptable injury risk associated with current helmet-supported weights were reduced with the use of airbags, then an increase in the helmet weight would not necessarily increase the injury risk above what is acceptable without an airbag. To test this hypothesis, a biodynamic simulation software, Dynaman, is used. But first, the data set which describes the crash scenario must be developed. The results of the simulations are described in a separate report. This report describes the input data set required by Dynaman to simulate the interaction of a helicopter pilot with a multiairbag system during a simulated crash. DTIC

N95-29132*# NYMA, Inc., Brook Park, OH.
USERS MANUAL FOR THE IMPROVED NASA LEWIS ICE ACCRETION CODE LEWICE 1.6 Final Report
WILLIAM B. WRIGHT Jun. 1995 97 p Supersedes N95-14295 and N90-20943
(Contract(s)/Grant(s): NAS3-27186; RTOP 505-68-10)
(NASA-CR-198355; E-9729; NAS 1.26:198355) Avail: CASI HC A05/MF A02

This report is intended as an update/replacement to NASA CR 185129 'User's Manual for the NASALewis Ice Accretion Prediction Code (LEWICE)' and as an update to NASA CR 195387 'Update to the NASA Lewis Ice Accretion Code LEWICE'. In addition to describing the changes specifically made for this version, information from previous manuals will be duplicated so that the user will not need three manuals to use this code. Author

N95-29210# Delaware State Coll., Dover, DE.
MODE OF HUMAN IMAGE REPRESENTATION AND ERROR CHECKING STRATEGIES IN COMPLEX VISUAL DISPLAYS Final Technical Report, 30 Sep. 1993 - 29 Sep. 1994
ALBERT B. MILLER 9 Dec. 1994 17 p
(Contract(s)/Grant(s): F49620-93-1-0608)
(AD-A290107; AFOSR-95-0005TR) Avail: CASI HC A03/MF A01

Experimental designs are currently being developed which will utilize the laboratory resources obtained under this grant for the purpose of examining error-checking strategies of human observers when monitoring complex visual displays. Some preliminary software has been developed and it is hoped that this development will be able to continue with the acquisition of research support. During the period of this grant, discussions were held with staff at the National Transportation Safety Board and with staff at the Aviation Safety Reporting System Office at Battelle which provided us with data base searches of human error incidents involved in aircraft accidents. This data has been extremely useful in our preliminary development of experimental protocols which will allow us to develop Department of Defense relevant research studies. DTIC

N95-29855# Federal Aviation Administration, Atlantic City, NJ.
THE EFFECT OF WEAR ON FIRE-BLOCKING LAYER MATERIAL EFFECTIVENESS
J. M. BARRIENTOS Jan. 1995 19 p
(AD-A291520; DOT/FAA/CT-TN94/16) Avail: CASI HC A03/MF A01

On Apr. 6, 1993, China Airline's MD-11 Flight 583 underwent severe turbulence caused by the inadvertent deployment of the wing leading edge slats. The aircraft experienced three violent pitch oscillations and a loss of altitude of about 5,000 feet which significantly damaged the interior of the cabin. Upon examination of the passenger seats in the cabin interior, excessive wear was noticed with the fire-blocking layer (FBL) material which encapsulates the foam cushions that protect them in the event of a fire. Concerns arose with this FBL material manufactured by Testori of Italy, as well as other FBL material in service, with regard to their effectiveness in protecting the foam cushions from fire. Samples of this type of material underwent several flammability tests at the FAA Technical Center International Airport, NJ, and chemical analysis and microscopic examination at Du Pont Fibers Laboratory in Wilmington, Delaware. DTIC

N95-29873# BioTechnology, Inc., Falls Church, VA.
DEVELOPMENT OF AN INTERVENTION PROGRAM TO ENCOURAGE SHOULDER HARNESS USE AND AIRCRAFT RETROFIT IN GENERAL AVIATION AIRCRAFT: PHASES 1 AND 2 Final Report
JAMES F. PARKER, JR., WILLIAM T. SHEPHERD (Federal Aviation Administration, Washington, DC.), WALTER J. GUNN (Arlington Associates, Daytona Beach, FL.), and DIANE G. CHRISTENSEN Jan. 1995 64 p
(AD-A290966; DOT/FAA/AM-95/2) Avail: CASI HC A04/MF A01

This report describes a study of shoulder harness installation and use rates in general aviation aircraft. Observations were made at six geographically separate areas to determine estimates of current installation and use rates. An expert panel was employed to identify important factors that affect installation and use of shoulder harnesses in general aviation aircraft. Analyses are presented to explain reasons for shoulder harness installation and use rates. An educational program is proposed to influence pilots to install and/or use shoulder harnesses in their general aviation aircraft. DTIC

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AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A95-89189

A MARKET PERSPECTIVE ON FANS

GERALD C. VANDEVOORT Honeywell, US and EMILY WILSON Honeywell, US (ISSN 0148-7191) 1993 4 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993

(SAE PAPER 932521; HTN-95-A1469) Copyright

The implementation of the Future Air Navigation System (FANS) will be evolutionary rather than revolutionary. Different generations of airplane models, each operating in a variety of operating enviroments will dictate more than a single growth path. How these markets will evolve is a function of our collective ability to assign benefits to specific equipage, to forge new business relationships and to address the market as a global one. Realization of the full benefits of FANS will depend on leadership: who and when. Author (Herner)

A95-89648

FAILURE DETECTION AND ISOLATION STRUCTURE FOR GLOBAL POSITIONING SYSTEM AUTONOMOUS INTEGRITY MONITORING

REN DA American GNC Corp, Chatsworth, CA, United States and CHING-FANG LIN Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 18, no. 2 March-April 1995 p. 291-297 refs

(BTN-95-EIX95282706656) Copyright

A new failure detection and isolation (FDI) structure is investigated for global positioning system (GPS) integrity monitoring in an integrated inertial navigation system (INS)/GPS navigation system. In the structure, a bank of auxiliary integrated INS/GPS Kalman filters, each of them processing a subset of the GPS measurements, are applied to provide high-accuracy detection references. The failure detection is then undertaken by checking the consistency between the state estimate of the main integrated INS/GPS Kalman filter and the auxiliaries. Two state propagators are also included in the FDI structure to reliably isolate the failed GPS measurement. The two propagators are alternatively reset with the data of the Kalman filter to increase their accuracy and thereby the failure isolation performance. The failure isolation is realized by testing the consistency between the state estimates of the auxiliary Kalman filters and the state propagator. The simulation results show that the FDI structure is capable of not only detecting the presence of a malfunctioning satellite that results in a large range error, but also identifying which satellite is malfunctioning. Author (EI)

A95-89649

STUDY OF STRAPDOWN NAVIGATION ATTITUDE ALGORITHMS

HOWARD MUSOFF Charles Stark Draper Lab, Inc, Cambridge, MA, United States and JAMES H. MURPHY Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 18, no. 2 March-April 1995 p. 287-290 refs

(BTN-95-EIX95282706655) Copyright

Typically coning motion has been used as the input to test the effectiveness of attitude algorithms. Jacobian elliptic functions are also shown to meet the criteria for a test input. Simulations using several of these inputs are performed on Miller's algorithm. Analytical evaluation of a Jacobian elliptic function input would be prohibitive. To alleviate this problem Richardson extrapolation is used to numerically evaluate the algorithms for each test input. Additionally, a method for improving all of the attitude algorithms using interpolation is presented. Author (EI)

A95-90079

GATELINK HIGHSPEED COMMUNICATIONS WITH PARKED AIRCRAFT

ERIK M. MILLER American Airlines, US and JONICA KEEL ELDEC Corp., Lynwood, WA, US (ISSN 0148-7191) 1993 6 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993

(SAE PAPER 932610; HTN-95-A1504) Copyright

As aircraft and aircraft systems increase in capability and complexity, the information necessary to monitor, maintain and trouble-shoot these systems also increases. This maintenance data, provided by aircraft condition monitoring systems (ACMS), onboard maintenance systems (OMS), and BITE data from individual Line Replaceable Units (LRUs), is growing at a rate never before encountered. Traditional methods of handling this plethora of data, such as quick access recorders (QARs) with removable media, are rapidly becoming too cumbersome to meet the efficiencies required in today's aviation business climate. Gatelink is a solution to this growing data management problem. It is the key element to the implementation of systems that provide automatic retrieval of data from an aircraft, expeditious dissemination of the data to the organizations that need it, and the subsequent analysis and processing of the data. This paper describes the Gatelink architecture, some of the potential applications for Gatelink, and its current development status. Author (Herner)

A95-90953

SCATTERING OF SHORT EM-PULSES BY SIMPLE AND COMPLEX TARGETS USING IMPULSE RADAR

G. C. GAUNAURD Naval Surface Warfare Center, Silver Spring, MD, US, H. C. STRIFORS National Defense Research Establishment, Sundbyberg, Sweden, S. ABRAHAMSSON National Defense Research Establishment, Linkoeping, Sweden, and B. BRUSMARK National Defense Research Establishment, Linkoeping, Sweden *In* Ultra-wideband, short-pulse electromagnetics; WRI International Conference, 2nd, Brooklyn, NY, October 8-10, 1992. A95-90904 New York, NY Plenum Press January 1993 p. 437-444 Research sponsored by the Independent Research Boards and Defense Materiel Adminstration (FMV), Sweden

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We study the transient scattering of short ultra-wideband (UWB) electromagnetic pulses by targets of simple and complex geometrical shapes using an impulse radar. The complex-shaped targets of are plastic scale-models of aircraft with metallized surface. The aircraft selected were a B-52 bomber (scale 1:72) and a C-130 transport (scale 1:48). For comparison we also use simple-shaped targets such as a metal sphere and a dielectric, air-filled, spherical shell. We display the various signature representations for these targets, both as theoretically predicted for the simple-shaped ones, and as observed from measured data. The actual shape of the interrogating pulses is theoretically modeled using a digital filter design technique together with pulse returns from a reference target, in this case the metal sphere. Using a second simple-shaped target, the dielectric spherical shell, we can then demonstrate that a good general agreement is obtained between theoretical predictions of pulse returns and measured data, both in the frequency domain and in the time domain. Author (Herner)

A95-90955

ULTRA-WIDEBAND ELECTROMAGNETIC TARGET IDENTIFICATION

D. G. DUDLEY Univ. of Arizona, Tucson, AZ, US, P. A. NIELSEN Univ. of Arizona, Tucson, AZ, US, and D. F. MARSHALL Univ. of Arizona, Tucson, AZ, US *In* Ultra-wideband, short-pulse electromagnetics; WRI International Conference, 2nd, Brooklyn, NY, October 8-10, 1992. A95-90904 New York, NY Plenum Press January 1993 p. 457-474

Copyright

For target identification, one of the most interesting parameters in the scattered signal is the time-of-arrival (TOA) of successive events. These times can often be related to physical parameters of the scattering object. For the hard acoustic sphere, the TOA is determined by the event in the post-reflection part of scatter impulse response at approximately 16 msec. We have considered two methods to extract the TOA of the first creeping wave from the observation. The first method examines the magnitude of the envelope of r(sub 0)(t) in the post-reflection portion of the observation. Preliminary noise free results indicate that the first local maximum occurs at about the same location as the 'bump' in the scattering impulse response. The second method examines the sume of squares of r. Author (Herner)

A95-91494
ANALYSIS OF APPROACH PATHS OF TWO AIRCRAFT
KEI SUGIMOTO Tokyo Univ., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 40-43 In JAPANESE
Copyright

Approach paths of an aircraft under the influence of an other aircraft were solved numerically in the horizontal plane. The problem of approach paths of two aircraft was formulated in terms of the optimal control problem. And then, the relative distance was limited as the state value constraint and each bank angle was limited as the control value constraint. Numerical results thus obtained explained fairly well the behavior of actual aircraft. It was also shown how approach paths depend upon performance functions, inequality constraints, and boundary conditions. Author (Herner)

A95-91536
INTRODUCTION OF THE GPS TO CIVIL AVIATION FIELD
IWAO EBINA Japan Airlines, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 280-283 In JAPANESE
Copyright

Satellite navigation systems such as the Global Positioning System (GPS) developed by USA is now in near practical use. If the accuracy and the reliability of navigation data derived from satellite navigation systems get superior to that derived from current navigation systems, a variety of applications are expected in civil aviation field. This paper describes GPS applications in the civil aviation field, current circumstances for introduction, and problems that have to be solved for practical use. Author (Herner)

A95-91537
ARRIVAL TRAFFIC HANDLING FOR A PARALLEL RUNWAY AIRPORT
SACHIKO ONOZUKA Electronic Navigation Research Inst., Japan, TSUKASA MATSUURA Electronic Navigation Research Inst., Japan, and NORIYASU TOFUKUJI Electronic Navigation Research Inst., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 302-305 In JAPANESE
Copyright

In the parallel runway airport, each airline's spots are allocated on either side of the Passenger Terminal Building (PTB). From the view of aircraft operation, it is desirable for arrivals to land on a runway on the inside of the PTB. However in heavy traffic, it results in complicated traffic handling. We conducted an air traffic control (ATC) simulation for arrival traffic handling, i.e., selection of landing runway depending upon initial approach fixes and the PTB. This paper compares two cases in terms of ATC operational procedures and airspace size. Author (Herner)

A95-91540
CCLA OPERATION ON MLS
SOUNOSUKE FUKUSHIMA Electronic Navigation Research Inst., Japan, HIDEO HASEGAWA Electronic Navigation Research Inst., Japan, HIROHISA TAJIMA Electronic Navigation Research Inst., Japan, and HISASHI YOKOYAMA Electronic Navigation Research Inst., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 334-337 In JAPANESE
Copyright

This paper describes an application of CCLA (Computed Center Line Approach) operation to non-parallel runways. Flight experiments of the CCLA were carried out at Sendai Airport in Japan. The ground equipment which were used for the CCLA flight experiment were a microwave landing system (MLS) AZ, an EL, and a Distance Measuring Equipment/Precision (DME/P). For the MLS receiver, the JLB-102E(JRC) is used. The CCLA calculation method is 3-dimensional Newton-Raphson algorithm. The resultant lateral position error is within the ICAO SARPs (Standards and Recommended Practices) limit. If the CCLA system integrity satisfies the requirement, CAT-2 operation would be possible. Author (Herner)

A95-91541
AERONAUTICAL SATELLITE COMMUNICATIONS USING THE ETS-5 SATELLITE
HIROMITSU WAKANA CRL, Ministry of Posts and Telecommunications, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 346-349 In JAPANESE
Copyright

This paper describes aeronautical satellite communications experiments using the Japanese ETS-5, Engineering Test Satellite-Five, which was launched on the geostationary orbit of 150 deg E in 1987. This is the first satellite experiment in the world using a commercial jet aircraft, a Boeing 747, over transoceanic flight routes. The experimental results of propagation measurements, bit error rate measurements, channel interference and beam scanning error of an airborne antenna, etc. are presented. Author (Herner)

A95-91575
PERFORMANCE EVALUATION TEST OF GPS/DGPS NAVIGATION SYSTEM INSTALLED IN THE NAL DORNIER 228: PRELIMINARY GROUND TEST RESULTS
TAKATSUGU ONO National Aerospace Lab., Japan and KAZUTOSHI ISHIKAWA National Aerospace Lab., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 554-557 In JAPANESE
Copyright

A real time Differential Global Positioning System (DGPS) was developed for the National Aerospace Laboratory (NAL) flight research airplane, Dornier 228, with a data link system from the ground to air. A preliminary ground test was conducted to evaluate the position accuracy of the system. In the test, the onboard and ground GPS receivers used the same antenna. In this paper, the GPS position accuracies of the stand alone mode and differential mode are compared. The result shows that differential mode improves position accuracy and it can eliminate Selective Availability (SA) error. Author (Herner)

A95-91576
ANALYSIS AND SCALE-MODEL EXPERIMENT OF PROPELLER DRIVING MOTOR FOR MICROWAVE-POWERED AIRPLANE
MASATAKA HASHIDATE National Aerospace Lab., Japan, KINGO TAKASAWA National Aerospace Lab., Japan, NOBUO YAMAMOTO SMIC, Japan, and KATUHIKO NAKAMURA SMIC, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 558-561 In JAPANESE
Copyright

A survey on weight reduction and the driving efficiency estimation of a 10 kW class electric motor which would be applied to the power plant of a microwave-powered airplane was done. A 1/5 scale model or 2 kW class experimental motor was manufactured. The efficiency of both the driving circuit and the motor itself is separately measured under parametric changed rotational speed and output torque conditions. Adding these measurements, the systems behavior at the partial loss of input voltage is investigated. As a whole, the required performance is satisfied. Author (Herner)

A95-91686
AIR TRAFFIC MANAGEMENT: THE FUTURE CHALLENGE
G. A. PAULSON National Air Traffic Services, UK 1991 8 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992 (Seminar 7: Developments and Requirements for Air Traffic Control-The 90s and Beyond)
(CONGRESS PAPER C428-7-145; HTN-95-21117) Copyright

National Air Traffic Services (NATS) is a major provider of, and planning and project implementation agency for, the United Kingdom's air traffic services. This paper addresses the challenges which NATS faces through the 1990's and into the next century. Its future strategy and major project plans for airport and area control air traffic services will be outlined in the context of international developments including ICAO's global future air navigation systems (FANS) planning and the European Air Traffic Control (ATC) harmonization program. This presentation will set the framework within which more specific ATC development issues will then be addressed.
Author (Herner)

A95-91687
AIRBOURNE COLLISION AVOIDANCE SYSTEMS - THE UK EXPERIENCE
R. M. ABLETT Civil Aviation Authority, UK 1991 8 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992 (Seminar 7: Developments and Requirements for Air Traffic Control-The 90s and Beyond)
(CONGRESS PAPER C428-7-146; HTN-95-21118) Copyright

The various forms of Airborne Collision Avoidance Systems (ACAS) are stated, but the paper concentrates on the form of ACAS being developed for US implementation on public transport aircraft; this is shown as Traffic Alert and Collision Avoidance System (TCAS) 2. The theoretical basis for the TCAS 2 algorithms are outlined. United Kingdom inputs to the development process are described. Brief guide-lines for the use of TCAS 2 are given but it is stressed that definitive instructions are to be taken from Company Operations Manuals. Future developments of the system are discussed. Author (Herner)

A95-91688
DEVELOPMENTS IN AIRFIELD LIGHTING
A. W. PUFFETT Defence Research Agency, UK 1991 5 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992 (Seminar 7: Developments and Requirements for Air Traffic Control-The 90s and Beyond)
(CONGRESS PAPER C428-7-147; HTN-95-21119) Copyright

Airfield markings, lighting and signs always make a significant contribution to the safety and regularity of aircraft operations. This paper discusses recent research at RAE Bedford that is likely to lead to more cost-effective approach and runway lighting and enhance the safety and efficiency of taxiway guidance systems.
Author (revised by Herner)

A95-91689
AUTOMATIC VEHICLE LOCATION AND AIRFIELD GROUND MOVEMENT
A. G. SCORER 1991 3 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992 (Seminar 7: Developments and Requirements for Air Traffic Control-The 90s and Beyond)
(CONGRESS PAPER C428-7-148; HTN-95-21120) Copyright

Datatrak has developed an integrated Vehicle Location, Reporting and Display system capable of producing regular high accuracy position reports over a wide area and capable of handling a large number of vehicles in a confined location. There are three main components to this system - they are the Navigation Network, The Data Network and the Display system. The Navigation Network covers 95% of all vehicle movements in the UK to an accuracy of better than 50 meters generally and significantly better if local differential techniques are employed. This is particularly relevant to airfields, where high accuracy and repeatability is required. The Data Network provided by Datamark makes very efficient use ofthe radio reporting channels as it is capable of 2000 reports per minute. These reports are sent on a sequential, non interfacing basis. Each unit having its own unique time slot in which to send back position, speed, direction, and status. Various display systems are available - including digitized maps covering anything from the United Kingdom down to a customer's own area or routes. Exception reports can be produced to alet users to special situations. Thus because ofthe design of the system it is very suited to applications with large numbers of vehicles in a confoined area. Author (Herner)

N95-28716*# Draper (Charles Stark) Lab., Inc., Cambridge, MA.
ERROR MODELING FOR DIFFERENTIAL GPS M.S. Thesis - MIT, 12 May 1995
GREGORY S. BLERMAN 12 May 1995 93 p
(Contract(s)/Grant(s): NAS9-18426)
(NASA-CR-188367; NAS 1.26:288367; CSDL-T-1241) Avail: CASI HC A05/MF A01

Differential Global Positioning System (DGPS) positioning is used to accurately locate a GPS receiver based upon the well-known position of a reference site. In utilizing this technique, several error sources contribute to position inaccuracy. This thesis investigates the error in DGPS operation and attempts to develop a statistical model for the behavior of this error. The model for DGPS error is developed using GPS data collected by Draper Laboratory. The Marquardt method for nonlinear curve-fitting is used to find the parameters of a first order Markov process that models the average errors from the collected data. The results show that a first order Markov process can be used to model the DGPS error as a function of baseline distance and time delay. The model's time correlation constant is 3847.1 seconds (1.07 hours) for the mean square error. The distance correlation constant is 122.8 kilometers. The total process variance for the DGPS model is 3.73 sq meters. Author

N95-28790# Federal Aviation Administration, Oklahoma City, OK. Civil Aeromedical Inst.
AUTOMATION AND COGNITION IN AIR TRAFFIC CONTROL: AN EMPIRICAL INVESTIGATION Final Report
O. U. VORTAC, MARK B. EDWARDS, DANA K. FULLER, and CAROL A. MANNING Feb. 1995 17 p Prepared in cooperation with Oklahoma Univ., Norman, Dept. of Psychology
(Contract(s)/Grant(s): DTFA02-91-C-91089)
(AD-A291932; DOT/FAA/AM-95/9) Avail: CASI HC A02/MF A01

A simulation of an air traffic control task was the setting for an investigation of the functions of external cues in prospective memory. External cues can support the triggering of an action or memory for the content of the action. We focused on memory for the content and manipulated the temporal characteristics of the external cue to disentangle two possible functions the cue can support: (1) An external cue visible during a retention interval could support rehearsal of the to-be-performed action; and (2) An external cue visible at the end of a retention interval could support retrieval of the to-be-performed action. Two experiments were conducted that converge on the same conclusion: the primary function of an external cue was to support retrieval. implications for the design of a computer interface to present prospective cues are discussed. DTIC

N95-28819# Civil Aeromedical Inst., Oklahoma City, OK.
CONVERSION OF THE TRACON OPERATIONS CONCEPTS DATABASE INTO A FORMAL SENTENCE OUTLINE JOB TASK TAXONOMY Final Report
MARK D. RODGERS and GENA K. DRECHSLER May 1995 68 p
(DOT/FAA/AM-95/16) Avail: CASI HC A04/MF A01

FAA Air Traffic Control Operations Concepts Volume 8: TRACON Controllers (1989) developed by CTA, Inc., a technical description of the duties of a TRACON air traffic control specialist (ATCS), formatted in User Interface Language, was restructured into a hierarchical formal sentence outline. To ensure that none of the meaning associated with a task or task element was lost during the conversion, the revised document was reviewed by subject matter experts (SMEs) consisting of four groups of six TRACON controllers and four quality assurance managers. SMEs looked for words, phrases, or acronyms not commonly used by TRACON controllers, and illogical sequencing of duties described in the document. Appropriate suggestions for change were implemented into the document before the next review. Six-hundred seventy-one changes were made to the document, with only seven of these changes made during the final review, confirming that an improved document resulted from the research. The restructured document is intended to assist in the identification of situation awareness information requirements. However, an easily understood, detailed description of duties performed by a TRACON ATCS has potential for use not only by researchers interested in TRACON ATCS tasks, but also by quality assurance investigation teams and training personnel. Author

N95-28887# Connecticut Univ., Storrs, CT.
MATSURV MULTISENSOR AIR TRAFFIC SURVEILLANCE Final Report, May 1993 - Aug. 1994
MURALI YEDDANAPUDI, YAAKOV BAR-SHALOM, KRISHNA R. PATTIPATI, T. KIRUBARAJAN, and SOMNATH DEB Jan. 1995 40 p
(Contract(s)/Grant(s): F30602-93-C-0090)
(AD-A292253; RL-TR-95-4) Avail: CASI HC A03/MF A01

In this report, the results of the work on multisensor air traffic surveillance and a description of MATSurv, a software tool for tracking multiple targets using measurements from asynchronous sensors, are presented. The work addresses the issues of modeling the target motion, estimating target states, and determining a consistent set of measurement-target associations. The specific objectives of this work are to formulate and solve the data association problem for actual tracking scenarios with multiple, multimodality sensor subsystems. Two phases of the work are described, namely, the tuning phase whereby the measurements are associated with the appropriate targets using the known target IDs to tune and validate the tracking filter, and the assignment phase whereby the association is carried out using a two-dimensional assignment algorithm developed at UConn. Also, the performance of the tracking and assignment algorithms using three representative sets of measurements is illustrated. DTIC

N95-29107 Stanford Univ., CA.
WIDE AREA DIFFERENTIAL GPS (WADGPS) Ph.D. Thesis
CHANGDON KEE 1994 147 p
Avail: Univ. Microfilms Order No. DA9414592

The Global Positioning System (GPS) has proven to be an extremely accurate positioning sensor, with an accuracy of 100 meters, for a wide variety of applications. However in some situations, such as aircraft precision approaches, higher accuracy is required. Conventional Differential GPS (DGPS) usually has an accuracy of 2 to 5 meters within 100 kilometers of the stationary calibration receiver, even with the expected levels of induced Selective Availability (SA) errors. To implement DGPS on a large scale, the total number of monitor stations needed to cover the continental United States to this accuracy would exceed 500. Wide Area Differential GPS (WADGPS) is a system that can limit the number of necessary monitor stations to 15 while achieving the same accuracy. WADGPS can reduce the overall cost and the operation cost of the system dramatically and can also increase the system's reliability and integrity. The WADGPS system comprises a master station and monitor stations distributed across the United States. It calculates and transmits a vector of error corrections to the users preferably via satellite. This correction vector consists of parameters describing the three-dimensional ephemeris errors, the satellite clock offsets including SA, and optionally the ionospheric time delay. The performance of a 15-station WADGPS network was investigated by simulation for users at sites across the United States, and the results indicated that normal GPS positioning errors can potentially be reduced by more than 95 percent using WADGPS. Experimental results from field tests using six monitor stations with a 1632-km minimum baseline from a dual frequency user showed a submeter positioning accuracy with no latency. These results strongly support the potential of WADGPS to give high positioning accuracy at a cost substantially lower than that of conventional DGPS. Dissert. Abstr.

N95-29542 Ohio Univ., Athens, OH.
AN INVESTIGATION INTO THE USE OF SATELLITE-BASED POSITIONING SYSTEMS FOR FLIGHT REFERENCE/ AUTOLAND OPERATIONS Ph.D. Thesis
DAVID WILLIAM DIGGLE 1994 146 p Avail: Univ. Microfilms Order No. DA9424040

An Interferometric Global Positioning System Flight Reference System (IGPS FRS) is implemented and flight tested on a transport category aircraft. This dissertation discusses the IGPS FRS theory and principles of operation, its architecture and integration with the aircraft, and the initial static calibration and flight-test performance results. The validity of the results is established by referencing them to a known ground test point and/or a laser tracking system. The principles underlying the operation of the IGPS FRS are similar to those used for kinematic surveying, and are also referred to as differential carrier-phase tracking with integer ambiguities resolved. Flight Reference System objectives include: 0.1 m accuracy rms (each axis); one or more updates per second; UTC (Universal Time, Coordinated) synchronization better than 0.1 ms; real-time, all-weather operation; and, repeatable flight paths. The latter requirement calls for full integration with the aircraft flight control system and coupled flight. Dissert. Abstr.

N95-29596 Wisconsin Univ., Madison, WI.
MODELING SPATIO-TEMPORAL DATABASES TO MEASURE THE PERFORMANCE OF THE GPS SATELLITE CONSTELLATION Ph.D. Thesis
WAEL MOHAMED ZAKOUT 1994 226 p
Avail: Univ. Microfilms Order No. DA9417227

The NAVSTAR (NAVigation Satellite Time And Ranging) Global Positioning System (GPS) is a satellite-based positioning system currently under development by the United States Department of Defense. The primary goal of the system is to support the U.S. military and its allies with real-time, all weather global navigational capabilities. For this reason, the system was designed so that at least four satellites are simultaneously in view from every point on the earth's surface. However, since the launch of the first GPS satellites in the late 1970's, numerous new techniques and methods have been developed to utilize the system, and hundreds of civilian applications have been added to those originally considered. GPS user requirements for applications such as navigation, geodetic surveying, time transfer, and photogrammetry vary in both accuracy and reliability. These requirements are a function of location and conditions, e.g., the use of GPS for land navigation in a large city requires more visible satellites than does ocean navigation. In this research investigation, a new technique was developed to incorporate user requirements as a performance measure of the GPS satellite constellation. To do so, a new approach was followed for modeling spatio-temporal databases using existing geo-relational Geographic Information Systems (GIS's). GPS users were sampled and their positional and navigational requirements reviewed. Then, the power of GIS technology was used to map these requirements into spatial data layers. Satellite coverage parameters were mapped into slices of spatial data, each slice representing the number of visible satellites and the corresponding dilution of precision (DOP) factors at a specific instant of time. The feasibility of interpolation between time slices was evaluated. Finally, the spatio-temporal model was tested on several available platforms to measure response times of existing hardware and software configurations. The system developed to measure GPS satellite constellation performance is flexible enough to incorporate additional measurement criteria. Dissert. Abstr.

N95-29733# Federal Aviation Administration, Washington, DC.
FEDERAL AVIATION ADMINISTRATION PLAN FOR RESEARCH, ENGINEERING AND DEVELOPMENT
Dec. 1994 203 p
(AD-A290952) Avail: CASI HC A10/MF A03

The Federal Aviation Administration (FAA) manages and operates the National Airspace System (NAS), a significant national resource. However, the demands on this system are continuously growing, and changing technologies provide the opportunity to improve system effectiveness and efficiency. Today, 23 of the country's largest airports are plagued by more than 20,000 hours of delay per year, which is projected to grow to 40 major airports by 2000. Nationally, air traffic delays cost the economy an estimated $6 billion in passenger delays and $3 billion in airline operating costs in 1990. At current trends, these costs will increase 50 percent within 10 years. Aviation and related industries are also challenged by energy and environmental factors, Currently, 45 percent of air carrier aircraft operating costs are for fuel, a large portion of which is from imported oil. While reducing fuel usage is a priority in terms of energy conservation, it is also an increasingly critical environmental issue, based on recent findings relating to nitrogen oxide emissions at high altitudes. Given the projected increases in aviation activity and stringent environmental standards being proposed in Europe and elsewhere, noise and engine emissions reductions are essential to the national aviation industry's viability. DTIC

N95-29880# Federal Aviation Administration, Washington, DC. Office of Aviation Policy and Plans.
TERMINAL AREA FORECASTS-FISCAL YEARS 1993-2010
1 Sep. 1994 557 p
(AD-A290835; FAA-APO-94-11) Avail: CASI HC A24/MF A04

This report contains forecasts of aviation activity of 875 airports in the United States for fiscal years 1993-2010. These include 401 airports with FAA air traffic control towers and radar approach control services and 29 FAA contract towers. For each airport, detailed forecasts are made for the four major users of the air traffic system: air carriers, air taxi/commuters, general aviation, and military. Summary table contain national, FAA regional, and State aviation data and other airport specific highlights. The forecasts have been prepared to meet the budget and planning needs of the FAA and to provide airport specific information that can be used by State and local aviation authorities, the aviation industry, and the general public. DTIC

N95-30031# Federal Aviation Administration, Atlantic City, NJ.
PROTOTYPE STOP BAR SYSTEM EVALUATION AT SEATTLE-TACOMA INTERNATIONAL AIRPORT Final Report
ERIC KATZ Nov. 1994 81 p
(AD-A290136; DOT/FAA/CT-94/62) Avail: CASI HC A05/MF A01

An interim United States stop bar specification was developed by the Federal Aviation Administration Technical Center. Using the guidance material contained in the interim specification, a full-scale prototype stop bar system was installed to protect runway 16R/34L at the Seattle-Tacoma International Airport (SEA). The system consists of two stop bars which incorporate both inset and elevated red light fixtures. Associated with each stop bar are green inset lead-on lights and microwave detectors that provide for automatic switching of the stop bar/lead-on light segments. Once installed, the SEA stop bar system was operated during air traffic controller training sessions and under actual low-visibility weather conditions for evaluation and user organization familiarization. Air traffic controller and air-carrier pilot questionnaires were distributed and returned to the FAA Technical Center for analysis after completion. The questionnaires were designed to solicit information regarding the effectiveness and reliability of the stop bar system. As a result of the evaluation, the U.S. stop bar lighting configuration, as developed and described in the interim specification, was found to be satisfactory and acceptable to user pilots. DTIC

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A95-87378
HYPERSONIC TECHNOLOGY EXPERIMENTAL VEHICLES (THE NEED FOR FLIGHT TESTING AT HYPERSONIC SPEED)
P. W. SACHER MBB Ottobrunn, Muenchen, Germany *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 65-81
Copyright

The record of experimental aircraft being employed to explore unknown flight regimes for advanced aircraft concepts is a very successful one. This is especially true concerning the extension of controlled flight to higher speed and high angles of attack. However there is a remarkable gap in the long series of successfully flown test vehicles: airbreathing propulsion has never been demonstrated for flight at Mach numbers beyond 5. It is proposed that flight testing at hypersonic speed is mandatory for the development of any kind of transportation system using airbreathing propulsion for Mach 5 and beyond, and for establishing confidence in the application of design tools for hypersonic vehicles. Critical key technology design problems and hypersonic design techniques are also discussed. Herner

A95-87414
EXPERIMENTAL AND NUMERICAL ANALYSIS OF A TWO-DUCT NOZZLE/AFTERBODY MODEL AT SUPERSONIC MACH NUMBERS
THOMAS M. BERENS Daimler-Benz Aerospace AG, Muenchen, Germany 1995 11 p. AIAA, International Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, April 3-7, 1995 Research sponsored by the German Ministry of Research and Technology
(AIAA PAPER 95-6085; HTN-95-92598) Copyright

For a hypersonic vehicle, a single expansion ramp nozzle highly integrated into the airframe can meet the challenging operating conditions arising from extremely different flight and ambient conditions along the flight trajectory. Applying single-duct nozzles, however, results in problems at off-design conditions where large exit areas of such exhaust systems do not match the nozzle pressure ratios appropriate to the flight envelope. To cope with extremely downward-directed thrust vectors, low thrust efficiency, and poor trimming and stability behavior in these cases, an efficient method is the injection of secondary air, e.g., the forebody boundary layer air and/or inlet bleed air, into the main nozzle flow. A nozzle/afterbody wind tunnel model with a primary engine nozzle duct and a secondary air injection duct was tested at supersonic ambient Mach numbers to investigate the complex afterbody flow field with a single expansion ramp involved. As experimental results, static pressure distributions along the model's surfaces are presented for selected combinations of the engine nozzle duct pressure ratio, for which the model geometry was designed, with different secondary air injection duct pressure ratios. For these operating conditions, two-dimensional Euler calculations of the complete nozzle/afterbody flow field are compared with the test data. Surface pressure distributions agree very well. Numerical Mach number distributions match flow field phenomena pictured in Schlieren photographs, revealing the complex interaction between the main nozzle jet, the injected secondary air flow, and the external afterbody flow field.

Gross thrust vectors are given as numerical results and demonstrate the strong impact of secondary air injection. Author (Herner)

A95-87564
AERODYNAMIC DESIGN AND OPTIMIZATION AT ALENIA D.V.D.
M. BORSI Alenia Aeronautica D.V.D., Torino, Italy *In* Computational methods in applied sciences; European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sept. 7-11, 1992. A95-87552 Amsterdam, The Netherlands Elsevier Science Publishers B.V. 1992 p. 253-259 Research sponsored by BRITE/ EURAM contract and European Economic Communvity
Copyright

The aircraft design is a complicated process that involves many disciplines like aerodynamics, structural design, loads, systems, etc. and requires a strong integration among them. Direct optimization, meaning the procedure that minimizes some objective function, is only part of the process that is mainly carried out as a trial-and-error exercise based on direct analysis methods. The present work focuses on aerodynamic design since this discipline is a key factor to improve the performance and flight qualities of a new aircraft. A review of aerodynamic design tools and of shape optimization techniques used at Alenia D.V.D. is given together with some considerations about their usage in an industrial environment. Author (Herner)

A95-87565
PRESSURE CONTROLLED SURFACES - A 3D INVERSE PANEL METHOD AS A DESIGN TOOL
H. SCHWARTEN Deutsche Airbus, The Netherlands and H. STUKE Deutsche Airbus, The Netherlands *In* Computational methods in applied sciences; European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sept. 7-11, 1992. A95-87552 Amsterdam, The Netherlands Elsevier Science Publishers B.V. 1992 p. 261-266
Copyright

The well known and widely spread panel code VSAERO is extended by an inverse option. While solving for the pressure on 'analysis patches' from given surface, the shape of 'design patches' is determined from given pressure distributions. To solve problems with both patch types present, the panel code is embedded into an iteration loop, which minimizes the sum of squared pressure deviations. The geometry representation of design patches is done in terms of B-Splines. Two examples of practical interest demonstrate the use of such a method during airplane design investigations. Author (Herner)

A95-87568
A TOOL FOR AIRFRAME SHAPING - IDEA AND APPLICATION
WITOLD JAWORSKI Warsaw Univ. of Technology, Warsaw, Poland and RAFAL SORNEK Warsaw Univ. of Technology, Warsaw, Poland (ISSN 0148-7191) 1993 4 p. SAE General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, KS, May 18-20, 1993
(SAE PAPER 931224; HTN-95-61195) Copyright

Considerations are outlined about design aid for airframe shaping in small computer-aided design (CAD) systems. Authors discuss problems associated with the adaptation of existing programs. The particular solution: a simple 3-dimensional lofting extension of popular CAD system (Auto CAD) is presented. A brief description of its practical use in a composite glider fuselage designing and manufacturing is also included. Author (Herner)

A95-87569
INFLUENCE OF WING SHAPHES ON SURFACE PRESSURE FLUCTUATIONS AT WING-BODY JUNCTIONS
SEMIH M. OLCMEN Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, US and ROGER L. SIMPSON Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 1 January 1994 p. 6-15
(Contract(s)/Grant(s): N00014-88-C-0291; N00014-90-J-1909)
(HTN-95-61196) Copyright

The body surface pressure fluctuations along the stagnation streamlines of several wing-body junctions were measured with microphones. The wing shapes are of a 3:2 semielliptical-nosed NACA-0020-tailed body, a parallel centerbody model, a tear drop shape, Sand 1850, NACA-0015, and NACA-0012. The oil-flow visualizations revealed the limiting streamline structure on the wall where the models were mounted. Measurements were conducted at a nominal reference velocity of 32.5 m/s and Reynolds number based on approach momentum thickness of 4450. Pressure-fluctuation measurements at the nose region show the existence of the bimodal pressure-fluctuation histograms and oil-flow visualization pictures show the primary separation regions, line of low shear, and the fish-tail-shaped wake region. The measurements show that the pressure fluctuations and the primary separation line location at the nose highly differ depending on the nose geometry. The histograms of the pressure-fluctuation data show that the fluctuations are different than Gaussian. A simple physical relationship between the pressure fluctuations and the body geometry is given.
Author (Herner)

A95-87570* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HEAD-ON PARALLEL BLADE-VORTEX INTERACTION
SOOGAB LEE Stanford Univ., Stanford, CA, US and DANIEL BERSHADER Stanford Univ., Stanford, CA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 1 January 1994 p. 16-22 Research sponsored by the U.S. Army Research Office
(HTN-95-61197) Copyright

An experimental and computational study was carried out to investigate the parallel head-on blade-vortex interaction (BVI) and its noise generation mechanism. A shock tube, with an enlarged test section, was used to generate a compressible starting vortex which interacted with a target airfoil. The dual-pulsed holographic interferometry (DPHI) technique and airfoil surface pressure measurements were employed to obtain quantitative flow data during the BVI. A thin-layer Navier-Stokes code (BV12D), with a high-order upwind-biased scheme and a multizonal grid, was also used to simulate numerically the phenomena occurring in the head-on BVI. The detailed structure of a convecting vortex was studied through independent measurements of density and pressure distributions across the vortex center. Results indicate that, in a strong head-on BVI, the opposite pressure peaks are generated on both sides of the leading edge as the vortex approaches. Then, as soon as the vortex passes by the leading edge, the high-pressure peak suddenly moves toward the low-peak-reducing in magnitude as it moves—simultaneously giving rise to the initial sound wave. In both experiment and computation, it is shown that the viscous effect plays a significant role in head-on BVIs. Author (Herner)

A95-87594
LONG DISTANCE PROPAGATION MODEL AND ITS APPLICATION TO AIRCRAFT EN ROUTE NOISE PREDICTION
KINGO J. YAMAMOTO McDonnell Douglas Aerospace-Transport Aircraft, Long Beach, CA, US and MICHAEL J. DONELSON McDonnell Douglas Aerospace-Transport Aircraft, Long Beach, CA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 1 January 1994 p. 207-209
(HTN-95-61221) Copyright

A three-dimensional long distance propagation model was developed based on the ray theory. The model was tested against propfan en route noise test data. The source strength of propfan determined with chase plane microphones was extrapolated by the model to the ground and then compared with en route noise measured on the ground. The comparison indicated an excellent agreement between measured and predicted data for both magnitude and location of the peak. It appears that en route noise level of the single rotation propeller is primarily determined only by the blade passing frequency at high altitude cruise missions. Author (Herner)

A95-88007
INTEGRATION OF AN HYPERSONIC AIRBREATHING VEHICLE: ASSESMENT OF OVERALL AERODYNAMIC PERFORMANCES AND OF UNCERTAINTIES
P. PERRIER DGT/DEA, Saint Cloud, France, P. ROSTAND DGT/DEA, Saint Cloud, France, B. STOUFFLET DGT/DEA, Saint Cloud, France, V. K. BAEV Russian Academy of Sciences, Novossibirsk, Russia, A. F. LATYPOV Russian Academy of Sciences, Novossibirsk, Russia, V. V. SHUMSKY Russian Academy of Sciences, Novossibirsk, Russia, and M. I. YAROSLAVTSEV Russian Academy of Sciences, Novossibirsk, Russia 1995 15 p. AIAA International Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, April 3-7, 1995
(AIAA PAPER 95-6100; HTN-95-92646) Copyright

A methodology for the integrated design of hypersonic vehicles has been presented. It relies on nose to tail CFD simulations obtained using a domain decomposition method which integrates different flow solvers, chosen to adapt locally the modelization to the flow physics, with the objective of attaining the 'just needed accuracy'. We present here a progress report on an effort to validate this methodology, through an analysis of the sensitivity of the predictions of overall performances to the level of modelization, and through the rebuilding of the aerothermodynamic characteristics of an 'Integrated Validation Object', for which wind tunnel data must be available. The objective is to obtain a quantification of the uncertainties on the predictions of a vehicle's global performances, by transposing to flight conditions the results of the ground analysis. Author (Herner)

A95-88100* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EQUIVALENT PLATE STRUCTURAL MODELING FOR WING SHAPE OPTIMIZATION INCLUDING TRANSVERSE SHEAR
ELI LIVNE University of Washington, Seattle, WA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 6 June 1994 p. 1278-1288
(HTN-95-20839) Copyright

A new technique for structural modeling of airplanes wings is presented taking transverse shear effects into account. The kinematic assumptions of first-order shear deformation plate theory in combination with numerical analysis, where simple polynomials are used to define geometry, construction, and displacement approximations, lead to analytical expressions for elements of the stiffness and mass matrices and load vector. Contributions from the cover skins, spar and rib caps, and spar and rib webs are included as well as concentrated springs and concentrated masses. Limitations of wing modeling techniques based on classical plate theory are discussed, and the improved accuracy of the new equivalent plate technique is demonstrated through comparison with finite element analysis and test results. Expressions for analytical derivatives of stiffness, mass, and load terms with respect to wing shape are given. Based on these, it is possible to obtain analytic sensitivities of displacements, stresses, and natural frequencies with respect to planform shape and depth distribution. This makes the new capability an effective structural tool for wing shape optimization. Author (Herner)

A95-88899
TAILLESS AIRCRAFT DESIGN-RECENT EXPERIENCES
ILAN KROO Stanford University, US *In* Symposium on Aerodynamics & Aeroacoustics, Tucson, AZ, March 1-2, 1993. A95-88892 Singapore World Scientific Pub. Co. Pte. Ltd. (Advanced Series on Fluid Mechanics) 1994 p. 207-229
Copyright

Several methods for achieving longitudinal trim of tailless aircraft with a desired stability level have been employed over the century of experimentation with such designs. This paper illustrates these approaches in recent applications, focusing on the advantages and problems associated with three very different flying wing concepts. Analyses and flight tests have demonstrated that is often possible to avoid the performance penalties once thought to be inherent in the tailless design. Example projects include the development of an upswept tailless aircraft for high altitude long endurance missions, a moderately-swept, foot-launched sailplane, and an unstable, oblique all-wing design. Author (Herner)

A95-89190
AIRCRAFT AERODYNAMIC ANALYSIS ON A PERSONAL COMPUTER (USING THE RDS AIRCRAFT DESIGN SOFTWARE)
DANIEL P. RAYMER Conceptual Research Corp., US (ISSN 0148-7191) 1993 7 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932530; HTN-95-A1470) Copyright

This paper discusses the creation of the aerodynamic analysis of a PC-based aircraft design program called 'RDS,' using the time-honored aerodynamic methods found in classical textbooks and the USAF DATCOM. Using this program, reasonably realistic aerodynamic results can be calculated in less than an hour given the geometric inputs which define an aircraft, such as component wetted areas, wing geometry, and cross-section areas. Aerodynamic analysis in RDS includes parasite drag (subsonic and supersonic), drag due to lift, lift curve slope, and maximum lift. Comparisons to T-38 data show good results. Author (Herner)

A95-89193
APPLICATION OF ARTIFICIAL NEURAL NETWORKS IN NONLINEAR AERODYNAMICS AND AIRCRAFT DESIGN
KAMRAN ROKHSAZ Wichita State Univ., Wichita, KS, US and JAMES E. STECK Wichita State Univ., Wichita, KS, US (ISSN 0148-7191) 1993 9 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932533; HTN-95-A1473) Copyright

The architecture and training of artificial neural networks are briefly described. Five applications of these networks to design and analysis problems are presented; three in aerodynamics and two in flight dynamics. The aerodynamics cases are those of a harmonically oscillating airfoil, a pitching delta wing, and airfoil design. The flight dynamic examples involve control of a super maneuver and a decoupled control case. It is demonstrated that highly nonlinear aerodynamic cases can be generalized with sufficient accuracy for design purposes. It is shown that although neural networks generalize well on the aerodynamic problems, they appear lacking comparable robustness in modeling dynamic systems. It is also shown that generalization appears to become weak outside of the training domain. Author (Herner)

A95-89194* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AERODYNAMIC TAILORING OF THE LEARJET MODEL 60 WING
REUBEN M. CHANDRASEKHARAN Learjet, Inc., US, VERONICA M. HAWKE Learjet, Inc., US, MICHAEL L. HINSON Learjet, Inc., US, ROBERT A. KENNELLY, JR. NASA. Ames Research Center, Moffett Field, CA, US, and MICHAEL D. MADSON NASA. Ames Research Center, Moffett Field, CA, US (ISSN 0148-7191) 1993 7 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932534; HTN-95-A1474) Copyright

The wing of the Learjet Model 60 was tailored for improved aerodynamic characteristics using the TRANAIR transonic full-potential computational fluid dynamics (CFD) code. A root leading edge glove and wing tip fairing were shaped to reduce shock strength, improve cruise drag and extend the buffet limit. The aerodynamic design was validated by wind tunnel test and flight test data. Author (Herner)

A95-89198
OPTIMIZATION OF WAVEDRIVER CONFIGURATIONS GENERATED FROM INCLINED CIRCULAR AND ELLIPTIC CONES
S. LIN National Taiwan Institute of Technology, Taipei, Taiwan, Republic of China and Y. LUO National Taiwan Institute of Technology, Taipei, Taiwan, Republic of China 3 Apr. 1995 9 p. Aerospace Planes and Hypersonics Technologies Conference, 6th, Chatta-

nooga, TN, April 3-17, 1995
(Contract(s)/Grant(s): NSRC-83-0424-E011-049)
(AIAA PAPER 95-6089; HTN-95-B0254) Copyright

Waverider configurations are derived from the general principle that any streamline of an inviscid flow can be viewed as part of a solid boundary of the flow. By suitably choosing the conical flowfields which are perturbations of the basic axisymmetric cone flow arising from small angle of attack and small cross-sectional eccentricity are used to generate waverider configurations. Nevertheless, there are an infinite number of possibilities for such waverider configurations. The problems of vehicle design are concerned with possible optimized configurations. By means of the calculus of variations, the optimum configurations of waverider having maximum lift-to-drag ratios subject to a suitable constraint, such as fixed lift, are investigated. Since these configurations provide not only high lift but also analytical results for aerodynamic properties, they are appropriate for the design of a modern aerospace plane.
Author (revised by Herner)

A95-89222
PRELIMINARY DESIGN OF A SINGLE ENGINE BUSINESS JET
DAVID W. LEVY University of Michigan, Michigan, US and MICHAEL HAILYE University of Michigan, Michigan, US (ISSN 0148-7191) 20 May 1993 13 p. SAE, General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, Kansas, May 18-20, 1993
(SAE PAPER 931253; HTN-95-B0278) Copyright

The preliminary design of a single engine business jet is presented. The airplane is intended to fill a market niche surrounded by several types of airplanes: single engine (piston and turboprop) and engry-level twin engine airplanes (turboprop and turbofan). The Williams-Rolls FJ44 turbofan engine, with a takeoff thrust rating of 1900 pounds, is chosen as the powerplant because of its low acquisition and maintenance costs. The airplane is designed to carry four persons and baggage 1500 n.m. with visual flight rules (VFR) reserves, and is intended to meet Federal Aviation Regulation (FAR) 23 standards - including the 61 knot single engine stall speed requirement. A parametric analysis of wing aspect ratio, thickness, and taper is performed to determine the best planform from the standpoint of weight, cruise speed, and cost. Maximum cruise speed is estimated to be 371 knots and the airplane purchase price is estimated to be 1.98 million. These results indicate the airplane will satisfy intended market niche. Author (revised by Herner)

A95-89223
SHOULD LARGE BUSINESS JETS HAVE FOUR UNDER THE WING?
JAN ROSKAM University of Kansas, Kansas, US (ISSN 0148-7191) 20 May 1993 16 p. SAE, General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, Kansas, May 18-20, 1993
(SAE 931256; HTN-95-B0279) Copyright

A preliminary design study is conducted of three very long range business jets. One has two engines mounted on the rear fuselage, like most existing business jets. The other two have two or four engines mounted under the wing. The paper show that the design takeoff weight of very long range business jets is extremely sensitive to three parameters: design range, design sfc and design lift/drag (L/D). Depending on the design range and wing loading, these airplanes are also critical in terms of available fuel volume. The paper gives an analysis of the pros and cons of either configuration. A cost comparison in terms of DOC (Direct Operating Cost) is also given. When considering both cost and takeoff weight, the 2-engines-under-the-wing design is shown to come out on top.
Author (revised by Herner)

A95-89224
THE FAA REGIONAL/COMMUTER AIRCRAFT FLIGHT LOADS DATA COLLECTION PROGRAM
TOM DEFIORE Federal Aviation Asministration, US and TERENCE BARNES Federal Aviation Administration, US (ISSN 0148-7191) 20 May 1993 6 p. SAE, General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, Kansas, May 18-20, 1993
(SAE PAPER 931258; HTN-95-B0280) Copyright

As a part of its International Aging Aircraft Research Program, the Federal Aviation Administration (FAA) is establishing a state-of-the-art Flight Loads Data Collection Program. Data collected in this program will provide the necessary mission profiles and load spectra information to characterize typical fleet service usage for the regional/commuter service life extension program. In addition, these data are applicable for both a safe life fatigue analysis and a damage tolerance fracture mechanics analysis. This paper describes the FAA approach and schedule for instrumenting fleet service aircraft, and the data reduction process. Author (revised by Herner)

A95-89251 National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LOW-SPEED WIND TUNNEL TESTS OF TWO WAVERIDER CONFIGURATION MODELS
ROBERT J. PEGG NASA Langley Research Center, Hampton, Virginia, US, DAVID E. HAHNE NASA Langley Research Center, Hampton, Virginia, US, and CHARLES E. COCKRELL, JR. NASA Langley Research Center, Hampton, Virginia,.US 1995 17 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, Tennessee, Apr. 3-7, 1995
(AIAA PAPER 95-6093; HTN-95-B0307) Copyright

A definitive measurement of the low-speed flight characteristics of waverider-based aircraft is required to augment the overall design database for this important class of vehicles which have great potential for efficient high-speed flight. Two separate waverider-derived vehicles were tested; one in the 14- by 22-Foot Tunnel and the other in the 12-Foot Low-Speed Tunnel at Langley Research Center. These tests provided measurements of moments and forces about all three axes, control effectiveness, flow field characteristics and the effects of configuration changes. This paper will summarize the results of these tunnels and show the subsonic aerodynamic characteristics of the two configurations. Author (Herner)

A95-90065
INTEGRATED THERMAL ENERGY MANAGEMENT (I-TEM): AN EVALUATION TOOL FOR AIRCRAFT
DAVE BROWN Wright Lab., US, STEVE SQUIER Sundstrand Aerospace, Rockford, IL, US, and GLEN SMITH Sundstrand Aerospace, Rockford, IL, US (ISSN 0148-7191) 1993 11 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(Contract(s)/Grant(s): F33615-91-C-3407)
(SAE PAPER 932577; HTN-95-A1490) Copyright

Sundstrand Aerospace, Rockford, Illinois, is developing an Integrated Thermal Energy Management (I-TEM) software assessment tool under contract to the Air Force Flight Dynamics Directorate at Wright Laboratory. The program is focused on developing a user-friendly, automated aircraft analysis tool capable of evaluating multiple thermal energy management approaches and assessing vehicle-level impacts. I-TEM compiles and uses extensive subsystem knowledge in areas of thermal management, electrical power, auxiliary power, actuation, environmental control and fuel systems to promote more efficient aircraft design. Vehicle level penalties are assessed and used to estimate overall vehicle performance for a given aircraft, mission, and heat load profile. The code incorporates fuel cooling loop analysis software, hydraulic system thermal modeling, environmental control system analysis, ram air recovery assessment, mission profile, atmospheric characterization, and heat transfer techniques. The analysis methodology is efficiently incorporated within a KAPPA-PC (R) expert system software program. The KAPPA-PC shell provides the framework for a user-friendly package that can be applied to a broad range of problems and applications. When conducting a thermal system analysis, the user has access to defaults and empirically derived system data allowing reasonable solutions to be obtained with minimal input information. The expert system is flexible, allowing expansion of a particular technical area or application to other aircraft, without rewriting the entire code or adversely affecting other sections of the software. I-TEM will be a valuable tool, dramatically decreasing the time and effort required by Air Force personnel to perform top-level thermal assessments of both existing and future aircraft systems. Author (Herner)

A95-90066
SPECIAL PURPOSE LANDING GEAR: A SURVEY OF HISTORICAL DESIGNS
HARRY C. RALPH Boeing Commercial Airplane Co., US (ISSN 0148-7191) 1993 9 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932579; HTN-95-A1491) Copyright

A landing gear system comprises a more compelling assembly of engineering skills than most other mechanical systems in the aircraft industry. Its importance to the successful design of an aircraft, ranks second only to the aircraft's wings and engines. It consists of several different engineering disciplines, and in continually in the public eye with regard to safety. In 1986, SAE Committee 5 created a panel of their members to compose a historical account of special purpose landing gear designs. Not a great deal of progress was made for quite a few years, at least not in terms of a publishable document. In 1991, it became apparent that a historical account in itself, did not have much objectivity unless the paper provided a certain amount of technical information. Such information had to be authentic, have an indexing system, and some form of categorization of the gear system or features. AIR 4846 was then initiated to fulfill this role, and this document describes the adopted document format. The primary objective of AIR 4846 is to establish a record of a variety of special purpose and extraordinary gears (and/or systems), discuss the pros and cons, and lessons learned, and last but by no means least, the reasons (where available) for the extraordinary design. This allows the document to be not only in compliance with the Committee 5's original requirement, but to be a practical benefit to future landing gear designers.
Author (revised by Herner)

A95-90067
CRITICAL SPEED ANALYSIS OF A NON-LINEAR STRAIN RING DYNAMICAL MODEL FOR AIRCRAFT TIRES
NED J. LINDSLEY Wright Lab., US and J. P. CUSUMANO Pennsylvania State Univ., PA, US (ISSN 0148-7191) 1993 11 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932580; HTN-95-A1492) Copyright

In this paper, a new model's critical speed predictions for five aircraft tires are compared with a shell finite element model's predictions (with and without centrifugal stiffening), a tread band model's predictions and experimental data. The model presented is a non-linear, shearable and extensible viscoelastic ring on viscoelastic foundation subjected to an internal pretensioning force and the full complement of inertial forces due to its rotation. This model is referred to as the ring model for the remainder of this paper. Critical speed (linear) analysis of the model's non-linear equations of motion yields results which are in good agreement with experimental data. The model is quicker and less memory intensive than the shell finite element model while still maintaining the same degree of accuracy. It is also more accurate than the tread band model since it incorporates the effects of transverse shear deformation and the full complement of inertial forces. Author (Herner)

A95-90068
COMPUTER AIDED DIAGNOSTIC TESTING OF INSTALLED FLIGHT CONTROL SERVO-ACTUATORS
J. L. BYBEE AAI/ACL Technologies, Hunt Valley, MD, US (ISSN 0148-7191) 1993 13 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932584; HTN-95-A1493) Copyright

Computer-controlled production and post-overhaul testing of servo-actuators is already a fact. Some challenges still exist for performing similar testing on components installed in the aircraft. An implementation of such a scheme is presented, using state-of-the-art technology. The technique is to perform diagnostic testing on flight control hardware sufficient to determine whether the component may be left on the aircraft. Author (Herner)

A95-90070
NEW SENSOR TECHNOLOGY FOR AIRCRAFT HYDRAULIC SYSTEM DIAGNOSTICS
FRANK E. BISHOP Pall Corp., New York, NY, US (ISSN 0148-7191) 1993 7 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932586; HTN-95-A1495) Copyright

Diagnostics can now be provided for aircraft hydraulic systems to determine continuously the on-condition health of operating components such as pumps, servovalves, and filters. Multi critical parameter data such as flow, temperature and differential pressure can be obtained to indicate internal wear and degradation of operating component surfaces before malfunction and failure occur. The data can be obtained during normal system operation and supplied directly to an on-board computer to be compared to maximum allowable component parameter limits for diagnosis of the health of the component and to indicate maintenance action required. The sensors monitoring flow, temperature, and differential pressure and their applications and use in the system are described. Signal conditioning interface modules are also described. Maintenance cost savings and reduced maintenance skill level are made possible by the new sensors. Additional benefits of reduced logistic support and reduced downtime will justify application of this new sensor technology. Author (Herner)

A95-90071
CARNARD: A NEW ROADABLE AIRCRAFT CONCEPT
PALMER STILES Florida Technological Univ., Orlando, FL, US (ISSN 0148-7191) 1993 6 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932601; HTN-95-A1496) Copyright

The CaRnard is a new concept in roadable aircraft which takes advantage of the geometric match between the canard aircraft configuration and the mid engine auto. Each high main wing is on a common pivot with one above the other. They rotate forward in a horizontal plane through an angle of about 110 degrees. In this position they are above and roughly parallel to the fuselage. Each canard also has a pivot near a front corner of the vehicle. They pivot forward about 180 degrees so that one is above the other.
Author (Herner)

A95-90072
ENGINEERING DESIGN OF STARCAR 3
STEVEN C. CROW Arizona Univ., AZ, US (ISSN 0148-7191) 1993 27 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932602; HTN-95-A1497) Copyright

Starcar 3 is being designed at the University of Arizona as a platform to demonstrate technologies important to the future of personal aviation. Among them are the Global Positioning System for precision guidance and control, automobile engines for propulsion, structural methods compatible with comfort and safety, and vehicle transformation to combine the benefits of automobiles and airplanes. Starcar 3 is a system of three modules: road module, passenger module, and sky module. The passenger and road modules together form a good automobile, and the passenger and sky modules together are a good airplane. This paper describes the road module, passenger module structure, rear suspension, sky module propulsion, and sky module structure.
Author (revised by Herner)

A95-90073
DESIGN AND STYLING OF AN ADVANCED FLYING AUTOMOBILE
MERKEL F. WEISS Stephen Blewett & Associates, US (ISSN 0148-7191) 1993 16 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932603; HTN-95-A1498) Copyright

A manufacturable, marketable, and functional advanced flying automobile has been designed. Engineering aspects, human factor, sociological aspects, and esthetic styling aspects of the design are addressed. The design proposal features a full-sized vehicle to be in compliance with expected Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA) requirements for the year 2000. The vehicle is a 300 kw, front engine, rear drive vehicle with a 6-speed semi-automatic transaxle and a fully active suspension. The body structure is made from recyclable yet lightweight advanced composite materials. The design utilizes a short fuselage with a pusher prop and a movable trim wing for stability. The vehicle is fully self-contained for flight and is designed to comply with expected Federal Aviation Authority (FAA) regulations. Author (Herner)

A95-90074
DESIGN METHODOLOGY AND INFRASTRUCTURES FOR FLYING AUTOMOBILES
BRANKO SARH Rohr, Inc., US (ISSN 0148-7191) 1993 24 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932604; HTN-95-A1499) Copyright

This paper addresses the design principles inherent in past flying automobiles and describes needed methodology for the development of future more advanced flying automobile concepts, emphasizing customer's needs and system requirements. The general aviation industry was analyzed and reasons for their stagnation/decline discussed. A proposal for a new private transportation system encompassing ground guided airways and its advantages for the private future air transportation are presented.
Author (Herner)

A95-90075
DESIGN AND ANALYSIS OF A TELESCOPIC WING
MIKE CZAJKOWSKI Rohr, Inc., US (ISSN 0148-7191) 1993 12 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932605; HTN-95-A1500) Copyright

Unique in the era of fail-safe aircraft design is the two-spar telescopic wing. This paper examines the structural integrity of this wing for use on the Advanced Flying Automobile. Presented is a summary of the preliminary stress analysis which identifies key areas of stress concentrations in the wing design. The analysis is based on several assumptions and hand calculations using classical and empirical equations available in the public domain. From a structural point of view, it would be ideal to have continuous instead of telescopic spars. However, the concept is structurally viable, and it is something that had to happen to benefit the overall design of a flying car. Author (Herner)

A95-90076
CONVERSION OF PRODUCTION AUTOMOTIVE ENGINES FOR AVIATION USE
JOHN E. KNEPP Electramotive, Inc., US and ROBERT L. MULLEN Electramotive, Inc., US (ISSN 0148-7191) 1993 12 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932606; HTN-95-A1501) Copyright

For decades converting automotive engines for aircraft use has attracted great interest. This is mainly because of the high cost of aircraft engines. Electramotive has adapted two automotive derived engines for aircraft, one for the 'Pond Racer', a Reno type unlimited air racer and the other a commercial crop duster. The method of selecting the engines, the components chosen, and the modifications made are discussed. Author (Herner)

A95-90084
ENGINE/AIRFRAME INSTALLATION CFD FOR COMMERCIAL TRANSPORTS: AN ENGINE MANUFACTURER'S PERSPECTIVE
RICHARD D. CEDAR GE Aircraft Engines, Cincinnati, OH, US, DONALD A. DIETRICH GE Aircraft Engines, Cincinnati, OH, US, and MARK J. OSTRANDER CFD Research Corp., Huntsville, AL, US (ISSN 0148-7191) 1993 8 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932623; HTN-95-A1509) Copyright

This paper explores the use of computational fluid dynamics (CFD) in the aerodynamic design of an engine installation on a commercial transport aircraft from the perspective of the engine manufacturer, although many of the issues are the same for the airframer. The paper begins with a discussion of the aerodynamic design of an engine installation and the identification of the role of CFD in this process. From this discussion it is concluded that the challenge for developers of CFD methods is to produce methods that are accurate and fast enough to be used early in the design process. With the currently available methods it is determined that installation CFD can play an important role in the detailed aerodynamic design of engine installations. The paper concludes with a description of how this has been achieved at GE Aircraft Engines by the use of the Chimera overset grid technique. Author (revised by Herner)

A95-90085
CIVIL AIRCRAFT PROPULSION INTEGRATION: CURRENT & FUTURE
DENNIS L. BERRY Boeing Commercial Airplane Group, US (ISSN 0148-7191) 1993 135 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932624; HTN-95-A1510) Copyright

The topics are presented in viewgraph form and include the following: factors influencing aircraft/engine installation, nacelle aerodynamic design, nacelle installation design considerations, test methods, and engine developments. Herner

A95-90086* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NASA EVALUATION OF TYPE 2 CHEMICAL DEPOSITIONS
THOMAS J. YAGER NASA. Langley Research Center, Hampton, VA, US, SANDY M. STUBBS NASA. Langley Research Center, Hampton, VA, US, W. EDWARD HOWELL NASA. Langley Research Center, Hampton, VA, US, and GRANVILLE L. WEBB NASA. Langley Research Center, Hampton, VA, US (ISSN 0148-7191) 1993 6 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932582; HTN-95-A1511) Copyright

Recent findings from NASA Langley tests to define effects of aircraft Type 2 chemical deicer depositions on aircraft tire friction performance are summarized. The Aircraft Landing Dynamics Facility (ALDF) is described together with the scope of the tire cornering and braking friction tests conducted up to 160 knots ground speed. Some lower speed 32 - 96 km/hr (20 - 60 mph) test run data obtained using an Instrumented Tire Test Vehicle (ITTV) to determine effects of tire bearing pressure and transverse grooving on cornering friction performance are also discussed. Recommendations are made concerning which parameters should be evaluated in future testing.
Author (Herner)

A95-90087
SOLID STATE POWER CONTROLLER TECHNOLOGY
JOHN G. NAIRUS United States Air Force, Wright-Patterson AFB, OH, US (ISSN 0148-7191) 1993 14 p. SAE, 1993 SAE Aerospace Atlantic Conference & Exposition, Dayton, OH, Apr. 20-23, 1993
(SAE PAPER 931422; HTN-95-A1512) Copyright

Advanced electrical power systems proposed for new platforms such as the More Electric Aircraft (MEA) require the use of electrical load management systems. A load management system is used to allow the aircraft power system to make critical decisions as to which loads at any given time are mission critical, flight critical, and non-critical. This removes a difficult responsibility from the pilot thus enabling the pilot to stay focused on actually flying the aircraft. A critical technology required to implement an electrical load management system is the Solid State Power Controller (SSPC). SSPCs are intelligent switching devices which have the ability to sense current and are programmable to trip and or current limit according to a current versus time curve. SSPCs can be electronically commanded either manually or by a microprocessor and are also able to be electrically reset after sensing and reacting to a fault condition thus enabling the SSPC to clear nuisance trips. The solid state nature of these devices implies no moving parts thus increasing lifetimes by orders of magnitude over equivalent electromechanical

switches which in turn improves power system reliability. Moreover, advanced power systems proposed for MEA are considering the use of 270 VDC power as opposed to conventional 400 Hz power. 270 DC power is more difficult to switch than conventional 400 Hz because of arcing associated with DC switching. Solid state devices are desirable for this type of switching because they are able to perform arcless switching faster than electromechanical relay can switch DC and extinguish the arc internal to the device.
Author (Herner)

A95-90089* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THE HIGH SPEED CIVIL TRANSPORT: A TECHNOLOGY CHALLENGE

ALAN K. MORTLOCK McDonnell Douglas Aerospace, Long Beach, CA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 3-8
(Contract(s)/Grant(s): NAS1-18378; NAS1-19345)
Copyright

It has been over 17 years since Concorde entered service with British Airways and Air France. The thirteen production aircraft are still safely operating and may extend their service life into the next century. We can appreciate the technical success Concorde has achieved. However, from the onset the aircraft was unable to achieve overall economic viability. Currently the aircraft does generate a yearly profit for British Airways which is privatized. Unacceptable airport noise and sonic boom overland levels were detrimental to the aircraft performing between many worldwide city pairs. On the horizon appears a possible successor to Concorde that will need to demonstrate environmental acceptability and economic viability shortly after the turn of the century. This vehicle has been labelled the High Speed Civil Transport (HSCT). I believe that we can overcome the environmental and economic goals based on encouraging market demand forecasts and technology improvements that are materializing in current research and development programs.
Author (Herner)

A95-90274

OPTIMUM DESIGN OF COMPOSITE STIFFENED WING PANELS - A PARAMETRIC STUDY

R. BUTLER University of Bath, Bath, UK Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 985 May 1995 p. 169-177
(HTN-95-01088) Copyright

The program VICONOPT is used to find the optimum (least mass) dimensions of a range of stiffened wing panels which are subject to buckling and material strength constraints and are loaded in axial compression with a sinusoidal manufacturing imperfection. Design plots are presented to show the effects that various rib spacings and stiffener types have on optimum design mass. A simplified model of a complete wing box is used to illustrate the design of a full wing panel and plots of optimum values of design variables at various stations along the wing have been obtained. The results were chosen to illustrate the practicality of optimization with reference to manufacture of a full wing panel and to show the effect of changing the sophistication of modeling and theory used for the range of panels considered. The important aspects of the choice of design variables and design concepts are highlighted and percentage savings in mass, compared with an optimum metal panel design, are given for the various (global) optima found along with some examples of (rejected) local optima.
Author (Herner)

A95-90281

CRACK GROWTH CHARACTERISTICS OF INTEGRALLY MACHINED STRINGER-SKIN PANELS

J. B. YOUNG Cranfield University, Cranfield, UK and M. ASHFAQ SHEIKH Cranfield University, Cranfield, UK Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 982 February 1995 p. 63-68
(HTN-95-01095) Copyright

The variation of the stress intensity factor (SIF) for cracks growing in integrally machined stiffened skin panels have been studied in an isotropic material. The stringer-skin panel has been modeled using the Nastran finite element system with allowance for crack tip singularity by use of crack tip elements. To allow for variations in stringer and skin geometry, three stiffness ratios (stringer stiffness-skin stiffness) were investigated. The stress intensity factors have been converted into nondimensionalized values of stress intensity factor coefficients (K(sub 1)/K(sub 0)). A damage tolerant and residual strength analysis has been carried out using an in-house computer program. Results indicate very little difference for the different stiffness ratios examined.
Author (Herner)

A95-90283

AERONAUTICAL TECHNOLOGY - RECENT ADVANCES AND FUTURE PROSPECTS

G. G. POPE Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 983 March 1995 p. 81-89
(HTN-95-01097) Copyright

Recent advances in technology are reviewed, with particular reference to work in the United Kingdom, and the process is outlined whereby these have progressed from fundamental research through to exploitation in marketable products. Aerodynamic, materials, propulsion and avionic aspects are discussed and successful applications described in commercial and combat aircraft and helicopters. Current and anticipated advances in technology are considered in the context of possible future applications, including brief consideration of the possibility of a new generation of supersonic transport aircraft. Lessons are drawn from past experience on actions necessary now if these advances are to be exploited successfully in improving the performance, or reducing the acquisition or operating cost, of the next generation of aircraft, without introducing an unacceptable level of risk.
Author (Herner)

A95-90458* National Aeronautics and Space Administration, Washington, DC.

SENSITIVITY OF ENGINE-INTEGRATED WAVERIDER PERFORMANCE TO STATIC MARGIN CONSTRAINT

C. TARPLEY University of Maryland, College Park, Maryland, US and M. LEWIS University of Maryland, College Park, Maryland, US 1995 11 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(Contract(s)/Grant(s): NAGW-3715; NCA2-611)
(AIAA PAPER 95-6142; HTN-95-B0377) Copyright

The performance of an engine-integrated wedge caret-wing waverider is optimized with respect to a set of geometric and flight attitude variables with constraints for steady state flight and static margin. The optimization is done with different values for the constraint on the static margin, and the resulting performances and geometries compared. This comparison is done for three performance parameters: L/D ratio, range coefficient, and a parameter that measures energy height gain per unit weight of fuel. The vehicle model incorporates a one-dimensional calculation on the forebody, inlet and wings. Fuel injection is done prior to the combustor entrance and flow properties are calculated with a one-dimensional model using a correlation for the shock shape in front of a transverse jet. The combustor is modeled as a shock-induced-combustion scramjet, and the nozzle flow field is calculated using the method of characteristics.
Author (Herner)

A95-90473

A WAVERIDER DERIVED HYPERSONIC X-VEHICLE

J. W. HANEY Rockwell International, Seal Beach, California, US 1995 12 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(AIAA PAPER 95-6162; HTN-95-B0392) Copyright

Economic and national security interests make it critical to continually advance aerospace research and manufacturing capabilities. To maintain growth in aeronautics, effort needs to be focused on areas of high speed flight not currently being pursued, but which have commercial and military applications in the early part of the 21st century. Unfortunately, advances in high speed vehicle development are being hampered by a lack of technology maturation in several critical areas of vehicle development and design. Currently, proposed commercial and military products cannot be confidently designed and analyzed with existing data bases, nor realistically tested in ground facilities. Gorund test facilities cannot simultaneously simulate the high Mach, high enthalpy, and range of Reynolds numbers necessary to characterize the high temperature flow physics along typical flight trajectories. With flight data to calibrate engineering analysis and ground test data, progress in aeronautics will be dramatic. This paper addresses an X-vehicle concept to explore the envelope of high speed flight by using waverider aerodynamics and hydrocarbon/endothermic fuels. A top level summary of past research performed by Rockwell International is presented. Author (revised by Herner)

A95-90643
FUNCTIONAL REQUIREMENTS OF AN AEROSPACE DESIGN REPRESENTATION PROGRAMMING INTERFACE
NARESH SHARMA Delft University of Technology, Netherlands and MATTIE SIM Delft University of Technology, Netherlands *In* AIAA Computing in Aerospace 10, San Antonio, TX, March 28-30, 1995. A95-90629 Washington, DC American Institute of Aeronautics and Astronautics 1995 p. 110-115
(AIAA PAPER 95-0967) Copyright

A Design Representation Programming Interface (DRPI) is a specification that enables integration of design tools in design systems. To arrive at a specification, our goal, in this paper, is to establish the functional requirements of a DRPI, based on service requirements that we have previously defined. Our goal is to arrive at a specification that can be applied throughout the aircraft design process, therefore the service requirements are based on an analysis of the high-level design activities, in terms of the design data and design process management needs and the information types and communication frequencies between activities. In this paper we perform an interpretation of the required services in order to form the basis for the functional requirements of a DRPI. Author (Herner)

A95-90752
AN INVESTIGATION OF PILOTING STRATEGIES FOR ENGINE FAILURES DURING TAKEOFF FROM OFFSHORE PLATFORMS
D. G. THOMSON, C. D. TAYLOR, N. TALBOT, R. ABLETT, and R. BRADLEY Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 981 January 1995 p. 15-25 Research sponsored by the UK Civil Aviation Authority
(HTN-95-92834) Copyright

An analysis technique capable of simulating the effect of engine failure during takeoff from offshore platforms is presented. Use is made of inverse simulation whereby the control actions required for a subject helicopter to follow a particular trajectory can be established. A mathematical representation of the towering takeoff procedure, and details of the modified inverse simulation technique needed to cope with the modeling of an engine failure are described. Detailed piloting accounts of the strategy used to fly the towering takeoff (with and without engine failures) are also given and are used to give qualitative validation of the analytical approach. Simulation results for a single engine failure of a transport helicopter during critical phases of a towering takeoff are presented. Finally, some directions for future work and potential applications of the technique are discussed. Author (Herner)

A95-90866
REPORT TO THE AEROSPACE PROFESSION; SETP SYMPOSIUM, 37TH, BEVERLY HILLS, CA, USA, SEPTEMBER
1993 Lancaster, Calif.. Society of Experimental Test Pilots (ISSN 0742-3705) September 1993 286 p.
(HTN-95-12142) Copyright

A conference was held at which a total of twenty papers was presented. Topics covered at this symposium included the following: test and evaluation of crew resource management; assessment of Russian vertical/short takeoff and landing (VSTOL) technology; F-14A/B air-to ground weapons separation program; C-17 Flight test update; manned flight test of an unmanned air vehicle; and development and flight testing of the HL-10 lifting body. For individual titles, see A95-90867 through A95-90872. Herner

A95-90868* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ASSESSMENT OF RUSSIAN VSTOL TECHNOLOGY EVALUATING THE YAK-38 'FORGER' AND YAK-141 'FREESTYLE'
ART NALLS USMC, US and MICHAEL STORTZ NASA. Ames Research Center, Moffett Field, CA, US *In* Report to the aerospace profession; SETP Symposium, 37th, Beverly Hills, CA, USA, September 1993. A95-90866 Lancaster, Calif. Society of Experimental Test Pilots (ISSN 0742-3705) September 1993 p. 40-59
Copyright

The dissolution of the Former Soviet Union (FSU) created new relationships between the world superpowers. Overnight, the Commonwealth of Independent States (CIS), formed from the remnants of the FSU, began the difficult transformation to a free market society. Military hardware that had once been highly classified and the basis for our own defense planning was now openly marketed at airshows around the world. 'Test' flights were available for potential customers and cooperative partnerships were explored between former adversaries. This environment permitted a visit to the Yakovlev Design Bureau, (YAK) for a vertical/short takeoff and landing (VSTOL) technology assessment. Yakovlev is the FSU's sole Design Bureau with experience in VSTOL aircraft and has developed two flying examples, the YAK-38 'FORGER' and YAK-141 'FREESTYLE'. This article reviews the performance of the YAK-38 'FORGER' and the YAK-141 'FREESTYLE'. Author (Herner)

A95-90869* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.
PROPULSION CONTROLLED AIRCRAFT RESEARCH
C. GORDON FULLERTON NASA. Dryden Flight Research Center, Edwards, CA, US *In* Report to the aerospace profession; SETP Symposium, 37th, Beverly Hills, CA, USA, September 1993. A95-90866 Lancaster, Calif. Society of Experimental Test Pilots (ISSN 0742-3705) September 1993 p. 78-88
Copyright

The NASA Dryden Flight Research Facility has been conducting flight, ground simulator, and analytical studies to investigate the use of thrust modulation on multi-engine aircraft for emergency flight control. Two general methods of engine only control have been studied; manual manipulation of the throttles by the pilot, and augmented control where a computer commands thrust levels in response to pilot attitude inputs and aircraft motion feedbacks. This latter method is referred to as the Propulsion Controlled Aircraft (PCA) System. A wide variety of aircraft have been investigated. Simulation studies have included the B720, F-15, B727, B747 and MD-11. A look at manual control has been done in actual flight on the F15, T-38, B747, Lear 25, T-39, MD-11 and PA-30 Aircraft. The only inflight trial of the augmented (PCA) concept has been on an F15, the results of which will be presented below. Author (Herner)

A95-90871
EARTHWINDS HILTON III: BALLOON PROJECT
DONALD D. ENGEN SETP Fellow, US *In* Report to the aerospace profession; SETP Symposium, 37th, Beverly Hills, CA, USA, September 1993. A95-90866 Lancaster, Calif. Society of Experimental Test Pilots (ISSN 0742-3705) September 1993 p. 237-244
Copyright

The Earthwinds Hilton Project is a highly technical assault on the distance records for ballons. This is a tremendously complex undertaking for which great planning and expense have been invested. The crew has trained well and is prepared to make this arduous and hazardous flight. The complex preparation needed, the finite aperture required for launch, the need for concurrent supportive systems of upper air and the ability to insert the balloon into them,

the reliance on two engines for electrical power and life support and the importance of sheets of 2 mil plastic not failing in some unforseen hazardous situation all create an atmosphere of great adventure.
Author (Hemer)

A95-90872* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.
DEVELOPMENT AND FLIGHT TESTING OF THE HL-10 LIFTING BODY
ROBERT W. KEMPEL PRC Inc., Edwards, CA, US and WENETH D. PAINTER National Test Pilot School, Mojave, CA, US *In* Report to the aerospace profession; SETP Symposium, 37th, Beverly Hills, CA, USA, September 1993. A95-90866 Lancaster, Calif. Society of Experimental Test Pilots (ISSN 0742-3705) September 1993 p. 262-286
Copyright

The Horizontal Lander 10 (HL-10) lifting body successfully completed 37 flights, achieved the highest Mach number and altitude of this class of vehicle, and contributed to the technology base used to develop the space shuttle and future generations of lifting bodies. Design, development, and flight testing of this low-speed, air-launched, rocket-powered, lifting body was part of an unprecedented effort by NASA and the Northrop Corporation. This paper describes the evolution of the HL-10 lifting body from theoretical design, through development, to selection as one of two low-speed flight vehicles chosen for fabrication and piloted flight testing. Interesting and unusual events which occurred during the program and flight tests, review of significant problems encountered during the first flight, and discussion of how these problems were solved are presented. In addition, impressions of the pilots who flew the HL-10 lifting body are given.
Author (Hemer)

A95-91491
AIRCRAFT SYMPOSIUM, 30TH, TSUKUBA, JAPAN, SEP. 30 - OCT. 2, 1992
Japan Japan Aerospace Association 1992 625 p. In ENGLISH and JAPANESE
(HTN-95-A1609) Copyright

A conference was held covering various topics in aerodynamics and aeronautics and produced numerous related papers. Topics included aerodynamics and computational fluid dynamics, aircraft design, engines, control and stability, control systems design, composite materials, flight mechanics and simulation, supersonic transports, hypersonic and vertical takeoff aircraft, and pilot performance. For individual titles, see A95-91492 through A95-91588.
Hemer

A95-91503
FLIGHT TESTING OF THE COMPOSITE MATERIAL BEARINGLESS ROTOR SYSTEM FOR THE HELICOPTER
TADASHI TSUKIJI Technical Research and Development Inst., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 112-115 In JAPANESE
Copyright

Flight testing of helicopters with the composite material bearingless rotor system was carried out from January to October 1991. A survey of flight performance, flight characteristics, rotor load and aeroelastic stability was successfully concluded. From the test results, this rotor system has proved to have sufficient aeroelastic stability and fulfilled the required design criteria for flight characteristics which was based on ADS-33A. The flight performance and rotor load data acquired will be beneficial to research and development for future helicopters.
Author (Hemer)

A95-91516
REQUIREMENTS FOR NEXT GENERATION SUPERSONIC TRANSPORTS
HIROSHI MIZUNO Japan Aircraft Development Corp., Japan and TAKASHI UCHIDA Japan Aircraft Development Corp., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 180-183 In JAPANESE
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In recent years, the development of next generation supersonic transports (SST) has been discussed internationally. Under this situation, we have studied the requirements for the SST. As the result of this study, we obtained the basic requirements from economical and technical points of view. These requirements are: passengers = 300; range = 6000 NM; cruising speed (Mach no.) = 2.2. Moreover, the next generation SST must also satisfy environmental requirements.
Author (Hemer)

A95-91517
THE CONCEPT OF HIGH SPEED COMMERCIAL TRANSPORTER STRUCTURE
TAKASHI HIRAMOTO Fuji Heavy Industry Ltd., Japan, TAKASHI UCHIDA Japan Aircraft Development Corp., Japan, YUTAKA SHIMOMURA Kawasaki Heavy Industries Ltd., Japan, and KENJI INABA Mitsubishi Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 184-187 In JAPANESE
Copyright

This paper presents a structural concept of HSCT (high speed commercial transport) that is supposed to be in a Mach 2.2 to 2.5 class. The primary factor that affects the structural concept is an aerodynamic heating caused in high speed flying. In this study, materials that have sufficient heat-resisting properties are considered and main structures are analyzed for heat transfer, thermal stress, and flight load.
Author (Hemer)

A95-91518
OVERVIEW OF FEASIBILITY STUDY ON PROPULSION CONCEPTS FOR HIGH SPEED CIVIL TRANSPORT
JUNICHI HIROKAWA Ishikawajima-Harima Heavy Industries Co. Ltd., Japan, NAOKI FUTATSUDERA Japan Aircraft Development Corp., Japan, and TOSHINORI SEKIDO Ishikawajima-Harima Heavy Industries Co. Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 188-191 In JAPANESE
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It is necessary for the realization of the next generation high speed civil transport to develop an economically viable and environmentally acceptable propulsion system. According to previous studies environmental acceptability, in particular, community noise polltuin has a great impact on the characteristics of propulsion system and airframe specifications. In this paper, an overview of the feasibility study on propulsion concepts is summarized and the result obtained in the recent study is presented. Engine configurations are the single bypass variable cycle engine with ejector nozzle and tandem fan engine. Design cruise speed in Mach 2.2 and design range is 6000 NM. The assessment is made by the mission analysis which is based on the supersonic transport/high speed transport (SST/HST) feasibility study by Japan Aircraft Development Corporation. Preliminary results indicate the optimum combination of bare engine and ejector nozzle exists, and this optimim engine is superior to tandem fan engine under current consideration.
Author (Hemer)

A95-91520
A CONCEPTUAL DESIGN OF THE SST WITHOUT HORIZONTAL TAIL
NAOKI HUTATSUDERA Japan Aircraft Development Corp., Japan and TAKASHI INOUE Kawasaki Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 204-207 In JAPANESE
Copyright

The studies for the next generation supersonic civil transport are now underway by aircraft industries around the world, including in Japan. The aircraft will be developed through international collaboration and its engineering commencement is to be expected in the near future. Japanese aircraft industries also plan to participate

in this collaboration. So, the study of the Japanese original baseline configuration has been started to find its technological key points. As the baseline, a configuration without a horizontal tail is selected. The purpose of this paper is to present the results of the basic conceptual design and the technological points to be solved.
Author (Herner)

A95-91521
CONCEPTUAL STUDY OF NEXT GENERATION HIGH-SPEED CIVIL TRANSPORT: A CANDIDATE WITH HORIZONTAL TAIL
EIJI KAWASHIMA Mitsubishi Heavy Industries Ltd., Japan, HIKARU TAKAMI Mitsubishi Heavy Industries Ltd., Japan, and NAOKI FUTATSUDERA Japan Aircraft Development Corp., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 208-211 In JAPANESE
Copyright
A conceptual design of a next generation high-speed civil transport (HSCT) has been made. A configuration has been determined to meet the specified criteria. The resulting aircraft has basically similar geometrical parameters with other supersonic cruise aircraft although it has unique characteristic features. Author (Herner)

A95-91531
COMPUTER AIDED STATIC AEROELASTIC ANALYSIS OF WING/PYLON/STORE COMBINATION
C. RUHI KAYKAYOGLU Istanbul Technical Univ., Istanbul, Turkey, K. CAN BAYAR Istanbul Technical Univ., Kocaeli, Turkey, and ALTUG UZUNALI Istanbul Technical Univ., Kocaeli, Turkey *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 258-261
Copyright
This paper presents a computer aided engineering solution method for the subsonic aeroelastic behavior of a flexible wing/store/pylon system fixed at the root chord. While an aerodynamic computer code based on a panel method of solution determines the external aerodynamic loads, the commercial software technology is readily available for the complete linear static structural analysis. Structures are represented by finite element models constructed from beams and thin shells of laminate composite materials. The loads encountered during constant angle of incidence are taken as the aerodynamic design loads in the analysis. The detailed pressure distribution at Mach number 0.6 is successfully transformed to equivalent concentrated forces applied at the node points of the finite element grids by using the pre-processing modules of the computer software used. The post processing of the solution data are accomplished with innovative computer graphics techniques. Results show that the tip displacement of the wing is an important design parameter while the stress induced near the pylon-store junction is on the order of the stress magnitude in the skin near the root of the wing. Author (Herner)

A95-91539
FLIGHT TEST OF STS RADIO CONTROLLED SCALE MODEL
NORIO SUZUKI Fuji Heavy Industry Ltd., Japan, YOHSUKE NAGAO Fuji Heavy Industry Ltd., Japan, and ATUSHI HITOMI Fuji Heavy Industry Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 318-321 In JAPANESE
Copyright
The Space Transporting System (HOPE) has been studied under contract with the National Space Development Agency (NASDA) and as an in-house study by FHI. It has been understood that the flying quality of HOPE has features which are low lift to drag (L/D) and poor lateral/directional controllability through this research. To evaluate these features and to obtain the know-how for experimenting with small-sized auto landing planes flight tests of a radio controlled scale model of HOPE have been accomplished as an in-house study of FHI. Author (Herner)

A95-91565
SIMULTANEOUS STRUCTURE/AERODYNAMIC DESIGN OPTIMIZATION FOR A FLEXIBLE WING STRUCTURE
SHINJI SUZUKI Tokyo Univ., Japan and ATSUSHI KITAMURA Tokyo Univ., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 470-473 In JAPANESE
Copyright
The simultaneous structure/aerodynamic design optimization for a flexible wing structure is presented. When the structural mass is optimized under the restraints on the stress caused by a deflection, the flexibility of the wing with the minimum mass may increase the induced drag. Consequently, the mass and the induced drag should be optimized simultaneously. The finite element method (FEM) structural analysis coupled with the lifting line theory is utilized to calculate both structural and aerodynamic characteristics of a flexible wing. The fuzzy decision making method using membership functions for each design object is applied to multi-objective optimization. The radius distribution of a wing is optimized sequentially by the use of a linear programming formulation. Author (Herner)

A95-91566
PRELIMINARY TESTS OF A TRANSONIC FLUTTER CONTROL WING MODEL
KENJI FUJII National Aerospace Lab., Japan, YASUKATSU ANDO National Aerospace Lab., Japan, HIROSHI WATSUSHITA National Aerospace Lab., Japan, MASATAKA HASHIDATE National Aerospace Lab., Japan, KOICHI SUZUKI National Aerospace Lab., Japan, YUKIO KOMATSU National Aerospace Lab., Japan, SEIZO SUZUKI National Aerospace Lab., Japan, MASAMITSU SUZUKI National Aerospace Lab., Japan, and AKIRA KOIKE National Aerospace Lab., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 474-477 In JAPANESE
Copyright
Studies on active control technology (ACT) for aeroelastic systems at National Aerospace Laboratory (NAL) are expanded to transonic flutter control. A cantilevered wing model for transonic wind tunnel tests was constructed and preliminary tests were made. From vibration tests and load tests results, structural characteristics were obtained with which a mathematical structural model was proved to be consistent. Static and dynamic aerodynamic characteristics were obtained from wind tunnel tests. The flutter boundary was predicted by data processing of wing responses due to turbulence.
Author (Herner)

A95-91567
SUPERSONIC FLUTTER ANALYSIS OF CANTILEVERED COMPOSITE PLATE-WINGS
YUJI MATSUZAKI Nagoya Univ., Japan and KOUSAKU TAKAHASHI Nagoya Univ., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 478-481 In JAPANESE
Copyright
This paper examines flutter and divergence boundaries of cantilevered flow. The Rayleigh-Ritz method is used to derive the governing equation with a modified version of the two-dimensional quasi-steady aerodynamic theory in which the velocity component of wing deflection at the leading edge is added. Numerical results have shown that the additional force component in the aerodynamic force has a significant influence on the flutter boundary. The flutter and the divergence boundary are strongly affected by bending-torsion coupling of the laminated plates and the forward/backward swept angle of the wing. Author (Herner)

A95-91572
SOME COMMENTS ON CURRENT RESEARCH AND DEVELOPMENT OF CIVIL VTOL AIRCRAFTS
MASANORI ENDOH National Aerospace Lab., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 510-513 In

JAPANESE
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Research and development programs of civil Vertical Takeoff and Landing (VTOL) aircraft are being carried out including the V-22 Osprey, Ishida TW-68, National Aerospace Laboratory (NAL) High Speed VTOL Transport and EUROFA. Some comments on the potential of these aircraft as well as the future propects of VTOL transports are described from various viewpoints. Author (Herner)

A95-91573
DUCTED FAN VTOL AND ITS FLIGHT CONTROL SYSTEM
SHOHEI NIWA Nagoya Univ., Japan and MASAYUKI SUZUKI Nagoya Univ., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 522-525 In JAPANESE
Copyright
Two types of ducted fan Vertical Takeoff and Landing (VTOL) research models are developed. One is driven by electric motors and the others by an engine. The aim of the development is to investigate the ability of the ducted fan VTOL as a platform for working tasks in air. The automatic flight control system for ducted fan VTOL is investigated and the control problems are studied which will arise when the VTOL is utilized as a working platform.
Author (Herner)

A95-91574
FLIGHT TEST MONITORING SYSTEM USING X-WINDOW
KENJI YAZAWA National Aerospace Lab., Japan, HAMAKI INOKUCHI National Aerospace Lab., Japan, MASATAKA SHIRAI National Aerospace Lab., Japan, and YASUFUMI WATANABE Meitec Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 550-553 In JAPANESE
Copyright
This paper presents a new Flight Test Monitoring System which modified the Flight test Analyzing and Monitoring System (FAMOS) of the Short Takeoff and Landing (STOL) Experimental Aircraft ASKA. The new Flight Test Monitoring System consists of modified FAMOS, and Engineering Work Station (EWS) SUN-4, Local Area Network (LAN), and X-terminal. FAMOS receives flight data from an aircraft by telemetry, and send some data to EWS using LAN. The data are displayed on the X-terminal as some data to EWS using LAN. The data are displayed on the X-terminal as some character information, time histories, and an animation of Head-Up Display Mode (HUD Mode) using the X-window graphical utility. The new Flight Test Monitoring System can be utilized anywhere in National Aerospace Laboratory's (NAL's) Local Area Network. Author (Herner)

A95-91636
INTEGRATED AIRCRAFT THERMAL MANAGEMENT AND POWER GENERATION
J. M. GAMBILL, D. E. WIESE, H. M. CLAEYS, D. S. MATULICH, and C. F. WEISS (ISSN 0148-7191) 1993 10 p. SAE, International Conference on Environmental Systems, 23rd, Colorado Springs, CO, July 12-15, 1993
(SAE PAPER 932055; HTN-95-21067) Copyright
The goal was to conceptually formulate a Subsystem Integration Technology (SUIT) approach which would provide significantly reduced weight and costs while increasing cooling and power generation capabilities. These goals were achieved with a new and innovative energy subsystem suite which integrates aircraft and engine subsystem power, cooling, pumping, and controls. The suite emphasizes the integration of power and cooling equipment rather than advances in component technologies, i.e. no hardware breakthroughs are required. A key feature of the suite is the Thermal and Energy Management Module (T/EMM) which integrates turbomachinery consisting of compressor, power turbine and cooling turbine with a generator, hydraulic pump, combustor, and controls. The T/EMM provides the power and cooling functions traditionally performed separately by an Auxiliary Power Unit (APU), an Airframe Mounted Accessory Drive (AMAD), and an Environmental Control System (ECS). The team's SUIT approach to energy subsystem integration potentially reduces subsystem weight by 25 percent and subsystem support costs by a factor of 2, while increasing cooling and power generation capacity by a factor of 3 over current fighter aircraft subsystems. The energy integration of the thermal management and power generation is the subject of this paper. Author (Herner)

A95-91729
THE USE OF STRUCTURAL OPTIMISATION WITHIN AEROSPACE
S. E. VINSON SD-Scicon UK Ltd, UK 1991 6 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 23: Structural Design & Validation)
(CONGRESS PAPER C428-23-008; HTN-95-21160) Copyright
With the advent of the motor car and the airplanre at the turn of the century, greater sophistication to design improvement was recognized as being required. This paper reviews the progress with structural optimization since then and discusses application areas where it is being used today. It concludes by looking to the future and suggesting how a more effective use of optimization within aerospace could be achievable. Author (Herner)

A95-91730
A BETTER THAN AVERAGE STRESS MODEL-PHOTOELASTIC ANALYSIS FOR AIRBUS DESIGN
E. W. O'BRIEN 1991 5 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 23: Structural Design & Validation)
(CONGRESS PAPER C428-23-005; HTN-95-21161) Copyright
A high level of structural efficiency is required in order to help achieve competitive performance from the modern commercial aircraft. Quality data are essential to confidently optimize complex aircraft with respect to stress, weight and cost is therefore essential and have necessitated improved analysis techniques - a better than average stress model (unfortunately the phrase is not original). Linear-elastic epoxy quickly determine precise stress levels and distributions of the required quality via reflective photoelasticity and strain gauges. Author (Herner)

A95-91732
IMPACT FINITE ELEMENT ANALYSIS, AS AN ALTERNATIVE TO THE TESTING OF WINDSCREENS FOR BIRD IMPACT
S. WRAY 1991 5 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 23: Structural Design & Validation)
(CONGRESS PAPER C428-23-196; HTN-95-21163) Copyright
This paper briefly reviews the application of finite element analysis to bird impact analysis. The results of a DYNA3D finite element analysis of bird impact on an aircraft transparency is dealt with. The validity of the analysis is discussed and aspects of the test data are considered. Finite element analysis will not, as yet replace testing of windscreens but can reduce the number of tests, with the resulting cost saving. Ultimately, with sufficient accumulative data and confidence in the material properties, tests coould be virtually eliminated. In reality testing will reduce to a random sample. Author (Herner)

N95-28704 ESDU International Ltd., London (England).
EJECTORS AND JET PUMPS: COMPUTER PROGRAM FOR DESIGN AND PERFORMANCE FOR STEAM/GAS FLOW
Dec. 1994 61 p
(ISSN 0141-4011)
(ESDU-94046; ISBN-0-85679-933-5) Avail: ESDU
ESDU 94046 introduces a Fortran program (ESDUpac A9446) for ejectors in which the primary and secondary flows are nonreacting gases that can be modelled as real. Three procedures are provided: a Quick Design Procedure, a Detailed Design Procedure and Performance Prediction. The first is based on experimental data obtained for steam ejectors pumping air at 20 degrees C. If other gases are handled the secondary mass flow rate is converted by the program to an equivalent rate based on the molar mass of the

secondary gas. For the second the input is a selection of entry and required exit pressures and flow rates, together with estimates of loss coefficients in the primary and secondary nozzles, mixing duct and diffuser. The program will optimize the ejector, calculating the primary nozzle and exit dimensions, and flow conditions throughout. For the third case, the ejector dimensions are input together with the loss factors again and a range of entry flow conditions and the program will calculate flow conditions throughout the ejector and at exit. The equations on which the program is based are fully specified, the input format required is set out in clear tables, and three worked examples illustrate the use of the procedures. Notes are provided on the mechanical design of steam/gas ejectors including the use of multi-stage units and annular- or multi-nozzles. Possible operating problems are discussed. The program is provided on disc (uncompiled) in the software volume, and compiled within ESDUview, a user-friendly shell running under MS-DOS that prompts on screen for input data. ESDU

N95-28707 ESDU International Ltd., London (England).
EFFECTS OF SMALL CHANGES ON RATE OF CLIMB
Oct. 1994 6 p
(ISSN 0141-4054)
(ESDU-94039; ISBN-0-856-79926-2) Avail: ESDU

ESDU 94039 gives simple formulae for the effect of small changes in thrust, power (for propeller-driven aircraft), weight and drag (assuming a parabolic drag law) at constant airspeed and, when divided by the acceleration factor, when airspeed is changing. Rather more complex formulae are also given for the effect of changes in airspeed and relative density. All the equations assume that there are no consequential changes in the other independent variables. Such formulae are useful in the adjustment of measured results to other conditions and in assessing changes required to achieve a specific performance level. ESDU

N95-28730*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RAPID AIRPLANE PARAMETRIC INPUT DESIGN (RAPID) Abstract Only
ROBERT E. SMITH *In* NASA. Lewis Research Center, Surface Modeling, Grid Generation, and Related Issues in Computational Fluid Dynamic (CFD) Solutions p 87 Mar. 1995
Avail: CASI HC A01/MF A10

RAPID is a methodology and software system to define a class of airplane configurations and directly evaluate surface grids, volume grids, and grid sensitivity on and about the configurations. A distinguishing characteristic which separates RAPID from other airplane surface modellers is that the output grids and grid sensitivity are directly applicable in CFD analysis. A small set of design parameters and grid control parameters govern the process which is incorporated into interactive software for 'real time' visual analysis and into batch software for the application of optimization technology. The computed surface grids and volume grids are suitable for a wide range of Computational Fluid Dynamics (CFD) simulation. The general airplane configuration has wing, fuselage, horizontal tail, and vertical tail components. The double-delta wing and tail components are manifested by solving a fourth order partial differential equation (PDE) subject to Dirichlet and Neumann boundary conditions. The design parameters are incorporated into the boundary conditions and therefore govern the shapes of the surfaces. The PDE solution yields a smooth transition between boundaries. Surface grids suitable for CFD calculation are created by establishing an H-type topology about the configuration and incorporating grid spacing functions in the PDE equation for the lifting components and the fuselage definition equations. User specified grid parameters govern the location and degree of grid concentration. A two-block volume grid about a configuration is calculated using the Control Point Form (CPF) technique. The interactive software, which runs on Silicon Graphics IRIS workstations, allows design parameters to be continuously varied and the resulting surface grid to be observed in real time. The batch software computes both the surface and volume grids and also computes the sensitivity of the output grid with respect to the input design parameters by applying the precompiler tool ADIFOR to the grid generation program. The output of ADIFOR is a new source code containing the old code plus expressions for derivatives of specified dependent variables (grid coordinates) with respect to specified independent variables (design parameters). The RAPID methodology and software provide a means of rapidly defining numerical prototypes, grids, and grid sensitivity of a class of airplane configurations. This technology and software is highly useful for CFD research for preliminary design and optimization processes. Author

N95-28820*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN EFFICIENCY STUDY OF THE SIMULTANEOUS ANALYSIS AND DESIGN OF STRUCTURES
ALFRED G. STRIZ (Oklahoma Univ., Norman, OK.), ZHIQI WU (Oklahoma Univ., Norman, OK.), and JAROSLAW SOBIESKI Apr. 1995 11 p Presented at the 1st World Congress of Structural and Multidisciplinary Optimization, ISSMO, Goslar, Germany, 28 May - 2 Jun. 1995
(Contract(s)/Grant(s): RTOP 505-63-50-06)
(NASA-TM-110168; NAS 1.15:110168) Avail: CASI HC A03/MF A01

The efficiency of the Simultaneous Analysis and Design (SAND) approach in the minimum weight optimization of structural systems subject to strength and displacement constraints as well as size side constraints is investigated. SAND allows for an optimization to take place in one single operation as opposed to the more traditional and sequential Nested Analysis and Design (NAND) method, where analyses and optimizations alternate. Thus, SAND has the advantage that the stiffness matrix is never factored during the optimization retaining its original sparsity. One of SAND's disadvantages is the increase in the number of design variables and in the associated number of constraint gradient evaluations. If SAND is to be an acceptable player in the optimization field, it is essential to investigate the efficiency of the method and to present a possible cure for any inherent deficiencies. Author

N95-28831*# Boeing Commercial Airplane Co., Seattle, WA.
THE EFFECTS OF DESIGN DETAILS ON COST AND WEIGHT OF FUSELAGE STRUCTURES
G. D. SWANSON, S. L. METSCHAN, M. R. MORRIS, and C. KASSAPOGLOU (Sikorsky Aircraft, Stratford, CT.) *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 601-622 Jan. 1993
(Contract(s)/Grant(s): NAS1-18889)
Avail: CASI HC A03/MF A04

Crown panel design studies showing the relationship between panel size, cost, weight, and aircraft configuration are compared to aluminum design configurations. The effects of a stiffened sandwich design concept are also discussed. This paper summarizes the effect of a design cost model in assessing the cost and weight relationships for fuselage crown panel designs. Studies were performed using data from existing aircraft to assess the effects of different design variables on the cost and weight of transport fuselage crown panel design. Results show a strong influence of load levels, panel size, and material choices on the cost and weight of specific designs. A design tool being developed under the NASA ACT program is used in the study to assess these issues. The effects of panel configuration comparing postbuckled and buckle resistant stiffened laminated structure is compared to a stiffened sandwich concept. Results suggest some potential economy with stiffened sandwich designs for compression dominated structure with relatively high load levels. Author

N95-28840*# Boeing Commercial Airplane Co., Seattle, WA.
GLOBAL COST AND WEIGHT EVALUATION OF FUSELAGE KEEL DESIGN CONCEPTS
B. W. FLYNN, M. R. MORRIS, S. L. METSCHAN, G. D. SWANSON, P. J. SMITH, K. H. GRIESS, M. R. SCHRAMM, and R. J. HUMPHREY *In* NASA. Langley Research Center, Third NASA Advanced Com-

posites Technology Conference, Volume 1, Part 2 p 807-836 Jan. 1993
(Contract(s)/Grant(s): NAS1-18889)
Avail: CASI HC A03/MF A04

The Boeing program entitled Advanced Technology Composite Aircraft Structure (ATCAS) is focused on the application of affordable composite technology to pressurized fuselage structure of future aircraft. As part of this effort, a design study was conducted on the keel section of the aft fuselage. A design build team (DBT) approach was used to identify and evaluate several design concepts which incorporated different material systems, fabrication processes, structural configurations, and subassembly details. The design concepts were developed in sufficient detail to accurately assess their potential for cost and weight savings as compared with a metal baseline representing current wide body technology. The cost and weight results, along with an appraisal of performance and producibility risks, are used to identify a globally optimized keel design; one which offers the most promising cost and weight advantages over metal construction. Lastly, an assessment is given of the potential for further cost and weight reductions of the selected keel design during local optimization. Author

N95-28841*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN AND EVALUATION OF A FOAM-FILLED HAT-STIFFENED PANEL CONCEPT FOR AIRCRAFT PRIMARY STRUCTURAL APPLICATIONS
DAMODAR R. AMBUR *In its* Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 839-857 Jan. 1993
Avail: CASI HC A03/MF A04

Geodesically stiffened structures are very efficient in carrying combined bending, torsion, and pressure loading that is typical of primary aircraft structures. They are also very damage tolerant since there are multiple load paths available to redistribute loads compared to prismatically stiffened structures. Geodesically stiffened structures utilize continuous filament composite materials which make them amenable to automated manufacturing processes to reduce cost. The current practice for geodesically stiffened structures is to use a solid blade construction for the stiffener. This stiffener configuration is not an efficient concept and there is a need to identify other stiffener configurations that are more efficient but utilize the same manufacturing process as the solid blade. This paper describes a foam-filled stiffener cross section that is more efficient than a solid-blade stiffener in the load range corresponding to primary aircraft structures. A prismatic hat-stiffener panel design is then selected for structural evaluation in uni-axial compression with and without impact damage. Experimental results for both single stiffener specimens and multi-stiffener panel specimens are presented. Finite element analysis results are presented that predict the buckling and postbuckling response of the test specimens. Analytical results for both the element and panel specimens are compared with experimental results. Derived from text

N95-28851 Defence Science and Technology Organisation, Canberra (Australia). Aeronautical and Maritime Research Lab.
HELICOPTER LIFE SUBSTANTIATION: REVIEW OF SOME USA AND UK INITIATIVES Technical Report
KEN F. FRASER Sep. 1994 27 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A290045; DSTO-TR-0062; DODA-AR-008-924) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

Military operators normally undertake programs to substantiate the fatigue lives of life-limited components in their major helicopter fleets. During recent visits to military helicopter representatives in the USA and the UK, the author discussed the motivation and the technical approach adopted by these operators for helicopter component life substantiation. Issues and programs of particular relevance to the Australian Defence Force are examined in this document. DTIC

N95-28896 ESDU International Ltd., London (England).
SHEAR FORCE, BENDING MOMENT AND TORQUE OF RIGID AIRCRAFT IN SYMMETRIC STEADY MANEUVERING FLIGHT
Dec. 1994 17 p
(ISSN 0141-3988)
(ESDU-94045; ISBN-0-85679-932-7) Avail: ESDU

ESDU 94045 uses for an aircraft of classical configuration at constant incidence the data identified in ESDU 94009 for aerodynamic load and mass of the components of a wing-filselage-nacelle combination. The wing shear force, bending moment and torque variations along the span are determined relative to a flexural axis for both an unswept high aspect ratio wing and for a swept, medium to high aspect ratio wing. In the former case a straight flexural axis is defined perpendicular to the aircraft plane of symmetry; a load applied to that axis will cause bending only, while a torque applied about it (in a plane normal to it) will cause only twist about it. In the latter case two types of flexural axis are considered: a straight axis parallel to the sweep line of the wing (an effective root chord is thereby defined that is not parallel to the aircraft plane of symmetry) about which the wing is assumed to bend and a curved axis along the span when the wing is assumed to bend and twist in a plane parallel to the aircraft plane of symmetry. For the fuselage the forces and moments are taken along the aircraft centre line in the plane of symmetry and only shear forces and bending moments are determined. Author

N95-28928* Advanced Rotorcraft Technology, Inc., Mountain View, CA.
APPLICATION OF PARALLEL PROCESSING TECHNOLOGY IN COMPLEX HELICOPTER ANALYSIS. PHASE 1 Final Report, 14 Jul. - 9 Dec. 1994
DHARMENDRA KUMAR and HOSSEIN SABERI 9 Dec. 1994 47 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract(s)/Grant(s): NAS2-14084)
(NASA-CR-197850; NAS 1.26:197850; AD-A288899; FR7060-001)
Avail: Issuing Activity (Defense Technical Information Center (DTIC))

Complex Helicopter Analysis codes, such as the Second Generation Comprehensive Helicopter Analysis System (2GCHAS), have been developed to provide a common framework for interdisciplinary design and analysis of rotorcraft systems. A major limitation on the effectiveness of the second generation comprehensive analysis codes is the slow processing speed that results from the computational intensity of the analysis software. The goal of phase I effort is to carefully define the specification for the parallelization opportunities in 2GCHAS, and apply the parallel processing techniques on a sample analysis to demonstrate a proof of concept. The Onyx Computer System from Silicon Graphics Inc. was chosen as the target machine for this effort as it has 4 processors and was available to ART. The tasks performed during the Phase 1 Base effort went beyond meeting the Phase 1 objectives and included the following: (1) Port of the most recent version of 2GCHAS Analysis to the Silicon Graphics Computer System; (2) Parallelize multicase analysis in 2GCHAS; (3) Choose an appropriate analysis component for parallelization in a single case analysis; (4) Parallelize Linearization Analysis and thereby reduce the overall runtime of a single case Linear System analysis; and (5) Identify candidates for future parallelization in 2GCHAS. In addition, efforts had been made to improve the eigenanalysis solution method. The result obtained from the Phase 1 effort showed over an order of magnitude reduction in the overall runtime for the sample problems due to parallelization, better RDB implementation, less overhead in a process invocation, improved analysis algorithm and faster machine speed. DTIC

N95-28977# Naval Air Warfare Center, Warminster, PA. Air Vehicle and Crew Systems Technology Dept.
EVALUATION OF PROPOSED AGILITY METRICS USING X-31 VS. F/A-18 FLIGHT DATA Final Report, Oct. 1993 - Sep. 1994
JULIETA E. BOOZ 30 Nov. 1994 38 p

(AD-A292573; NAWCADWAR-95012-4.3) Avail: CASI HC A03/MF A01

This report is an evaluation of the specific agility metrics and tactical agility metrics as described in Veda Technical Report 33158-94U/P3553-003, Aircraft Fighter Agility: Theory, Advanced Metrics, and Simulation. The agility metrics were applied to six engagements flown between the X-31 and the F/A-18. A comparison was done to determine if the agility metrics correlated with the results from the engagements flown (e.g. did the more agile aircraft get the win). The results indicate that applying these agility metrics to correlate with the win or loss of an engagement did not provide consistent predictions as to which aircraft would score a win. Evaluation of the data from the engagements indicate that what determined which aircraft achieved the win (by obtaining a missile kill) was that aircraft which was the first to maneuver into an offensive position within the weapons firing solution. This was primarily done by generating the higher acceleration rate or by obtaining a higher initial acceleration value. DTIC

N95-29016 ESDU International Ltd., London (England).
EFFECTS OF CABIN PRESSURE ON CLIMB AND DESCENT RATES
Nov. 1994 6 p
(ISSN 0141-4054)
(ESDU-94040; ISBN-0-856-79927-0) Avail: ESDU

ESDU 94040 discusses how the maximum cabin pressure differential and the rate of change of cabin pressure affect rates of climb and descent, particularly of civil aircraft. The cabin pressure differential is governed by the capability of the air-conditioning system, the strength of the fuselage and the maximum operating altitude of the aircraft. A sketch illustrates how cabin pressure and pressure differential affect operating altitude and indicates where aircraft of various classes operate. Excessive rate of change of pressure can build up a differential pressure across the eardrums and at 0.5 lbf/sq in (3.45 kN/sq m) would cause pain. For civil aircraft restricting the rate of change of cabin pressure is a major factor in determining descent profile and has also to be considered in climb although to a lesser extent. A further sketch illustrates possible climb and descent profiles chosen to maintain cabin pressure and its rate of change within the necessary restrictions while not exceeding cabin differential pressure limits. ESDU

N95-29027*# Lockheed Aeronautical Systems Co., Marietta, GA.
ADVANCED COMPOSITE STRUCTURAL CONCEPTS AND MATERIALS TECHNOLOGIES FOR PRIMARY AIRCRAFT STRUCTURES: ADVANCED MATERIAL CONCEPTS Final Technical Report, Jun. 1989 - Jun. 1992
KREISLER S. Y. LAU (Lockheed Missiles and Space Co., Palo Alto, CA.), ABRAHAM L. LANDIS (Lockheed Missiles and Space Co., Palo Alto, CA.), ANDREA W. CHOW (Lockheed Missiles and Space Co., Palo Alto, CA.), and RICHARD D. HAMLIN (Lockheed Missiles and Space Co., Palo Alto, CA.) Feb. 1993 106 p
(Contract(s)/Grant(s): NAS1-18888; RTOP 510-02-13-01)
(NASA-CR-4485; NAS 1.26:4485) Avail: CASI HC A06/MF A02

To achieve acceptable performance and long-term durability at elevated temperatures (350 to 600 F) for high-speed transport systems, further improvements of the high-performance matrix materials will be necessary to achieve very long-term (60,000-120,000 service hours) retention of mechanical properties and damage tolerance. This report emphasizes isoimide modification as a complementary technique to semi-interpenetrating polymer networks (SIPN's) to achieve greater processibility, better curing dynamics, and possibly enhanced thermo-mechanical properties in composites. A key result is the demonstration of enhanced processibility of isoimide-modified linear and thermo-setting polyimide systems. Author

N95-29122 Massachusetts Inst. of Tech., Cambridge, MA.
A NUMERICAL METHOD FOR MODELLING WINGS WITH SHARP EDGES MANEUVERING AT HIGH ANGLES OF ATTACK Ph.D. Thesis
STEPHANE LUCIEN MONDOLONI 1994
Avail: Issuing Activity (MIT Libraries, Rm. 14-0551, Cambridge, MA 02139-4307)

An unsteady, high-order panel method is presented for computing the loading on wings maneuvering at high angles of attack. The method is also applicable to wing-tail combinations. Wakes are allowed to shed from sharp user-prescribed edges. These wakes are model led using desingularized vortex filaments. Global wake properties such as the motion of the centroid and overall extent of the tip vortices agree with experiments, yet predicting the local spiral structure requires more resolution. The effect of the wake desingularization and time stepping scheme on the stability of the discrete vortex sheet is investigated. This yields important information for understanding the behavior of the discretized vortex sheet. Higher core sizes decrease the instabilities, with greatest effect on the smallest wavelength. Unseparated, steady and unsteady calculations of wings with different planforms, and a wing-tail case are compared to experiment, theory and other panel methods with excellent agreement. The initial normal force on impulsively plunged two-dimensional plates and delta wings with separation is shown to be sensitive to the positioning of the shedding vortex. This sensitivity is removed by positioning the shedding vortex along the streakline emanating from the edge, which should prove useful to users of vortex-filaments trying to capture unsteady loading. An aspect ratio one wing is impulsively plunged with leading-edge separation. The rollup and unsteady loading is sensitive to numerical core size. This sensitivity diminishes as the overall resolution is increased. Steady-state comparisons to theory, experiments and code show good agreement except near the apex region. Dissert. Abstr.

N95-29322# Florida Atlantic Univ., Boca Raton, FL.
HIGH-AND LOW-FREQUENCY DYNAMICS OF ISOLATED BLADES AND ROTORS WITH DYNAMIC STALL AND WAKE Final Report, 1 Jan. 1991 - 30 Sep. 1994
GOPAL H. GAONKAR 23 Nov. 1994 50 p
(Contract(s)/Grant(s): DAAL03-91-G-0007)
(AD-A290358; ARO-28123.10-EG) Avail: CASI HC A03/MF A01

This report investigates the effects of dynamic stall and three-dimensional wake on the trim results of control inputs and periodic responses and on the damping levels of isolated hingeless rotors. The investigation covers three items: (1) the convergence characteristics of trim and damping with respect to the number of harmonics of the wake model in the presence of dynamic stall; (2) a parametric study of trim and damping over a broad range of system parameters such as thrust level and advance ratio; and (3) a comprehensive correlation with the measured lag-regressive-mode damping. The correlation includes near-zero thrust conditions in hover and forward flight to high-thrust and highly stalled conditions in forward flight with advance ratio as high as 0.55 and shaft angle as high as 200. The convergence characteristics and the parametric study are based on a three-bladed isolated rotor in propulsive trim: the cantilever blades have flap bending, lag bending and torsion degrees of freedom. In the correlation study, the root-flexure-blade assembly of the experimental rotor is modeled by an offset-hinged, rigid flap-lag model and by three elastic blade models, which differ in modeling the root flexure The experimental rotor is soft inplane and operated untrimmed. The ONERA dynamic stall models of lift drag and pitching moment and a finite-state three-dimensional wake model are used. The control inputs and periodic responses as well as the Floquet transition matrix about that response are obtained by periodic shooting with damped Newton iteration. The damping levels are generated from a full Floquet analysis that includes all the structural and aerodynamic states in trim analysis and eigenanalysis. For lag damping predictions in the presence of dynamic stall, at least nine wake harmonics are required even for the low frequency lag-regressive mode. DTIC

N95-29362 Defence Science and Technology Organisation, Melbourne (Australia). Aeronautical and Maritime Research Lab.

UNMANNED AERIAL VEHICLE TECHNOLOGY
KEITH CAMERON Feb. 1995 46 p
(DSTO-GD-0044; AR-008-372) Copyright Avail: Issuing Activity

This document reviews the individual technologies that may be applicable to Unmanned Aerial Vehicles (UAVs). In addition, an overview of UAV systems as a new technology and their integration into the existing ADF (Australian Defence Force) structure is considered. Despite there having been considerable interest in UAVs for at least twenty years they have not as yet become a significant factor in operations outside Israel and possibly the Gulf war. The number of operational systems is limited as is the specific technology base of UAVs. This may be due to the need for a significant market before industry will make the investment needed and to the users not being able to acquire suitable systems. Therefore, it is likely that slow progress will be made until a 'critical mass' is achieved when industry will make the needed investment to produce the range of UAVs required by the users. Author

N95-29426# DACCO SCI, Inc., Columbia, MD.
THE USE OF ELECTROCHEMISTRY AND ELLIPSOMETRY FOR IDENTIFYING AND EVALUATING CORROSION ON AIRCRAFT Final Report, 15 Jun. - 15 Dec. 1994
CHESTER M. DACRES, BRIAN C. TAGGART, CHARLES R. ANDERSON, and PAM WHISNANT 15 Dec. 1994 84 p Prepared in cooperation with Marietta Lab.
(Contract(s)/Grant(s): F49620-94-C-0042)
(AD-A290249) Avail: CASI HC A05/MF A01

Electrochemical corrosion testing using AC impedance measurement and ellipsometry has been performed on aircraft aluminum 2024-T3 samples. The AC Impedance technique was used to acquire a precise low-frequency impedance signature of corroding painted aircraft aluminum which will be used to develop a simple, yet powerful, sensor for the early detection and measurement of corrosion processes on aircraft. The use of ellipsometry and DC electrochemical techniques, have verified that the low-frequency impedance spectrum obtained from the AC Impedance technique is representative of the corrosion process for painted aircraft aluminum 2024-T3. Based on these findings, several versions of prototype electrode sensors were developed capable of obtaining this signature utilizing a two-electrode approach. These in-situ electrode sensors were extensively tested using AC Impedance, electrochemistry, ellipsometry, and X-ray Photoelectron Spectroscopy. Results indicate the ability of the electrode sensors to non-destructively monitor the corrosion process on aircraft aluminum 2024-T3 and to withstand harsh operating environments. DTIC

N95-29437# Naval Postgraduate School, Monterey, CA.
APPLICATIONS OF DIGITAL VIDEO AND SYNTHETIC ENVIRONMENTS TO UNMANNED AERIAL VEHICLES M.S. Thesis
FRANKLIN J. TIPTON Sep. 1994 91 p
(AD-A291875) Avail: CASI HC A05/MF A01

The current Army Unmanned Aerial Vehicle (UAV) system has two problems: (1) it does not provide for the direct distribution of live UAV video throughout command posts across their local area networks; and (2) it lacks an automated trainer. To solve the video distribution problem, I studied the UAV system, video compression techniques, and local area network protocols to develop the video distribution model. The approach taken for developing the simulator included researching the operational characteristics of the UAV system and studying the creation of synthetic environments. This thesis develops an architecture for extending the distribution of live UAV video inside the command post using a local area network. It recommends distributing full-motion UAV video over an Asynchronous Transfer Mode (ATM) local area network using the motion Joint Photographic Expert Group (JPEG) compression technique. Additionally, I created an interactive, UAV Simulator using the IRIS Performer applications program interface and C++. The simulator is implemented using two networked workstations which replicate the functions of the air vehicle and mission payload operators. The workstations communicate across a local area network using the Distributed Interactive Simulation (DIS) protocol. DTIC

N95-29445 Defence Science and Technology Organisation, Melbourne (Australia). Aeronautical and Maritime Research Lab.
ESTIMATION OF AERODYNAMIC LOAD DISTRIBUTIONS ON THE F/A-18 AIRCRAFT USING A CFD PANEL CODE
HOWARD A. QUICK Mar. 1995 44 p
(DSTO-TR-0147; AR-008-420) Copyright Avail: Issuing Activity

The computational fluid dynamics panel method code VSAERO has been used to estimate the aerodynamic load distributions on the stabilators, fins and aft fuselage of the F/A-18 aircraft for steady sideslip and steady roll conditions. Three separate VSAERO models have been developed to obtain results for these conditions. These are a symmetric F/A-18 model, a starboard fin model and a starboard stabilator and fin model. Difficulties in modelling the vortices separating from the leading edges of the stabilators and fins at moderate angles of attack have restricted the range of conditions for which the method has been used. Author

N95-29457 Naval Postgraduate School, Monterey, CA.
DESIGN AND EVALUATION OF A LQR CONTROLLER FOR THE BLUEBIRD UNMANNED AIR VEHICLE M.S. Thesis
BRIAN T. FOLEY Sep. 1994 86 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A289769) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The modern aerospace controls engineer is provided with a variety of powerful tools to aid in the design and testing of digital flight control systems. The current fiscal environment requires extensive validation of all aerospace based systems through simulation and hardware-in-the-loop testing prior to implementation. This work explores the design and evaluation of an Automatic Flight Control System (AFCS) for the Bluebird Unmanned Aerial Vehicle (UAV). Software tools such as MATLAB and MATRIXx are used to evaluate the dynamic stability of the aircraft model and Linear Quadratic Gaussian algorithms are used to obtain the appropriate controller. Graphical design applications such as SIMULINK and SystemBuild are then used to build a visual block diagram model of the aircraft dynamics and link it with the designed controller. Using this model, the control system response to commanded inputs and external disturbances was evaluated. DTIC

N95-29503# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
AGARD FLIGHT TEST TECHNIQUES SERIES. VOLUME 13: RELIABILITY AND MAINTAINABILITY [FIABILITE ET MAINTENABILITE]
JAN M. HOWELL (Test Wing, 0412th, Edwards AFB, CA.) Feb. 1995 63 p
(AGARD-AG-300-VOL-13; ISBN-92-836-1014-8) Copyright Avail: CASI HC A04/MF A01

This AGARDograph outlines the rudiments of reliability and maintainability (R&M) evaluations conducted during initial flight test programs. Many organizations, both military and civilian, prefer to defer R&M evaluations until the new equipment has been delivered to the eventual user. The U.S. Air Force Flight Test Center has long conducted R&M evaluations during initial flight test and has found value in that process. This document discusses, first, the objectives of the early evaluations. Then, the acquisition process and the test planning process, as they relate to R&M evaluations, are presented. The test planning section discusses the data needed for a successful R&M evaluation and the sources of such data. The conduct of the test, analysis of results, and subsequent reporting methods are delineated. Follow-up actions that are needed after the test are considered. In conclusion, the document lists some R&M considerations for the future. Author

N95-29565# Federal Aviation Administration, Atlantic City, NJ.
AIRCRAFT ADVANCED MATERIALS RESEARCH AND DEVELOPMENT PROGRAM PLAN Final Report
PETER SHYPRYKEVICH and JOE SODERQUIST Nov. 1994 56 p
(AD-A290542; DOT/FAA/CT-94/106) Avail: CASI HC A04/MF A01

This report describes the FAA research and development plan in Aircraft Advanced Materials and Structures. The Aircraft Advanced Materials Research and Development Plan identifies technology issues that must be addressed to accomplish the FAA mission. DTIC

N95-29787 Yale Univ., New Haven, CT.
AN ANALYTIC MODELING AND SYSTEM IDENTIFICATION STUDY OF HELICOPTER DYNAMICS Ph.D. Thesis
STEVEN W. HONG 1993 254 p
Avail: Univ. Microfilms Order No. DA9415860

This thesis applies well-known concepts in maximum likelihood estimation theory to the parametric system identification of a high-order state-space model of rotor craft hover dynamics, and describes an analytic modeling investigation which achieves a partial resolution of differences between the identified and theoretical models. A mathematically derived dynamic model was used to generate the time-domain likelihood function. A model parametrization scheme employing equivalent physical coefficients was used in order to avoid the overparametrization of high order state-space models, to permit an examination of analytic modeling assumptions, and to gain physical insight into system dynamics. The likelihood function was optimized by first using the genetic algorithm approach to locate the neighborhood of the global maximum. This method proved highly effective in locating the near-optimum of a highly multimodal parameter space contour, and when used in conjunction with a gradient-based optimization method, has led to an identified state-space model from flight test data which includes coupled fuselage/rotor dynamics, including main rotor inflow. An examination of the estimated equivalent physical coefficients revealed differences between nominal and estimated parameter values, indicating the need for model improvement in several areas. This study provides a rigorous analytic explanation for the estimated parameters in one important case involving main rotor blade structural flexibility. The investigation has shown that including blade flexibility is important in correctly predicting coupled fuselage/rotor dynamics. Blade structural dynamics were modeled using a Lagrangian formulation of the normal modes approach and has resulted in excellent agreement between flight test and theory, especially in the high frequency range. Dissert. Abstr.

N95-30226*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LOW-SPEED WIND-TUNNEL INVESTIGATION OF THE STABILITY AND CONTROL CHARACTERISTICS OF A SERIES OF FLYING WINGS WITH SWEEP ANGLES OF 50 DEG
SCOTT P. FEARS (Lockheed Engineering and Sciences Co., Hampton, VA.), HOLLY M. ROSS, and THOMAS M. MOUL Jun. 1995 148 p
(Contract(s)/Grant(s): RTOP 505-68-30-01)
(NASA-TM-4640; L-17427; NAS 1.15:4640) Avail: CASI HC A07/MF A02

A wind-tunnel investigation was conducted in the Langley 12-Foot Low-Speed Tunnel to study the low-speed stability and control characteristics of a series of four flying wings over an extended range of angle of attack (-8 deg to 48 deg). Because of the current emphasis on reducing the radar cross section (RCS) of new military aircraft, the planform of each wing was composed of lines swept at a relatively high angle of 50 deg, and all the trailing-edge lines were aligned with one of the two leading edges. Three arrow planforms with different aspect ratios and one diamond planform were tested. The models incorporated leading-edge flaps for improved longitudinal characteristics and lateral stability and had trailing-edge flaps in three segments that were deflected differentially for roll control, symmetrically for pitch control, and in a split fashion for yaw control. Three top body widths and two sizes of twin vertical tails were also tested on each model. A large aerodynamic database was compiled that could be used to evaluate some of the trade-offs involved in the design of a configuration with a reduced RCS and good flight dynamic characteristics. Author

N95-30335*# California Polytechnic State Univ., San Luis Obispo, CA. Dept. of Aeronautical Engineering.
DEVELOPING A WORKSTATION-BASED, REAL-TIME SIMULATION FOR RAPID HANDLING QUALITIES EVALUATIONS DURING DESIGN Final Report
FREDERICK ANDERSON and DANIEL J. BIEZAD 1994 10 p
(Contract(s)/Grant(s): NCC2-800)
(NASA-CR-198831; NAS 1.26:198831) Avail: CASI HC A02/MF A01

This paper describes the Rapid Aircraft DynamIcs AssessmeNt (RADIAN) project - an integration of the Aircraft SYNThesis (ACSTNT) design code with the USAD DATCOM code that estimates stability derivatives. Both of these codes are available to universities. These programs are then linked to flight simulation and flight controller synthesis tools and resulting design is evaluated on a graphics workstation. The entire process reduces the preliminary design time by an order of magnitude and provides an initial handling qualities evaluation of the design coupled to a control law. The integrated design process is applicable to both conventional aircraft taken from current textbooks and to unconventional designs emphasizing agility and propulsive control of attitude. The interactive and concurrent nature of the design process has been well received by industry and by design engineers at NASA. The process is being implemented into the design curriculum and is being used by students who view it as a significant advance over prior methods. Author

06
AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A95-90058
MIL-STD-461/MIL-STD-704 INVESTIGATION
KENNETH BREZINSKI Naval Air Warfare Center, US and ED TAYLOR Naval Air Warfare Center, US (ISSN 0148-7191) 1993 15 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932561; HTN-95-A1483) Copyright

Industry has expressed concern that the electromagnetic emission limits of MIL-STD-461 are incompatible with the AC voltage waveform distortion limits of MIL-STD-704. Previous industry studies have attempted to establish a correlation between MIL-STD-704 and MIL-STD-461 limits, but lacked the comprehensive analyses/data required for a meaningful document comparison. This paper presents the Navy's on-going effort to investigate equipment compatibility with MIL-STD-461 and MIL-STD-704 limits and to establish a correlation between the limits of MIL-STD-461 and MIL-STD-704. A preliminary investigation was conducted to review the requirements, test methods, and measurement relationships of specifications MIL-STD-461, MIL-STD-462, MIL-STD-704, and MIL-STD-1399. Author (Hemer)

A95-90069
SECOND GENERATION SMART ACTUATOR
R. W. DELLER HR Textron, Inc., US (ISSN 0148-7191) 1993 9 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932585; HTN-95-A1494) Copyright

An actuator has been developed and qualified with all loop-closure and redundancy management functions covered by an electronic package physically located on the actuator manifold assembly. The actuator meets or exceeds all Original Equipment

Manufacturer (OEM) requirements of the F/A-18 aileron servocylinder design with the single restriction of 99 C maximum oil temperature. While the actuator has performed well at temperatures in excess of 135 C, present MIL-SPEC derating for electronics limit the allowable operating range. The basic design offers potential advantages in the areas of weight, maintainability, self-diagnostics, and ease of integration. Author (Herner)

A95-90270
AUTOMATIC IDENTIFICATION OF MODAL DAMPING FROM FLOQUET ANALYSIS
J. NAGABHUSHANAM Indian Institute of Science, Bangalore, India and G. H. GAONKAR Florida Atlantic University, Boca Raton, FL, US American Helicopter Society, Journal (ISSN 0002-8711) vol. 40, no. 2 April 1995 p. 39-42
(HTN-95-01084) Copyright

A practical method is proposed to identify the mode associated with the frequency part of the eigenvalue of the Floquet transition matrix (FTM). From the FTM eigenvector, which contains the states and their derivatives, the ratio of the derivative and the state corresponding to the largest component is computed. The method exploits the fact that the imaginary part of this (complex) ratio closely approximates the frequency of the mode. It also lends itself well to automation and has been tested over a large number of FTMs of order as high as 250. Author (Herner)

A95-90632* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INTEGRATED PERFORMANCE AND RELIABILITY SPECIFICATION FOR DIGITAL AVIONICS SYSTEMS
ERIC W. BREHM Advanced System Technologies, Inc., Englewood, CO, US and ROBERT T. GOETTGE Advanced System Technologies, Inc., Englewood, CO, US *In* AIAA Computing in Aerospace 10, San Antonio, TX, March 28-30, 1995. A95-90629 Washington, DC American Institute of Aeronautics and Astronautics 1995 p. 20-28 Research sponsored by NASA
(AIAA PAPER 95-0953) Copyright

This paper describes an automated tool for performance and reliability assessment of digital avionics systems, called the Automated Design Tool Set (ADTS). ADTS is based on an integrated approach to design assessment that unifies traditional performance and reliability views of system designs, and that addresses interdependencies between performance and reliability behavior via exchange of parameters and result between mathematical models of each type. A multi-layer tool set architecture has been developed for ADTS that separates the concerns of system specification, model generation, and model solution. Performance and reliability models are generated automatically as a function of candidate system designs, and model results are expressed within the system specification. The layered approach helps deal with the inherent complexity of the design assessment process, and preserves long-term flexibility to accommodate a wide range of models and solution techniques within the tool set structure. ADTS research and development to date has focused on development of a language for specification of system designs as a basis for performance and reliability evaluation. A model generation and solution framework has also been developed for ADTS, that will ultimately encompass an integrated set of analytic and simulated based techniques for performance, reliability, and combined design assessment. Author (Herner)

A95-90665
THE ROLE OF SIMULATIONS IN 777 FSEU DEVELOPMENT
HOWARD PEARCE Boeing Defense and Space Group, Seattle, WA, US, DONALD TONG Boeing Defense and Space Group, Seattle, WA, US, DON PRATT Boeing Defense and Space Group, Seattle, WA, US, and JOE FINCO Boeing Defense and Space Group, Seattle, WA, US *In* AIAA Computing in Aerospace 10, San Antonio, TX, March 28-30, 1995. A95-90629 Washington, DC American Institute of Aeronautics and Astronautics 1995 p. 308-316
(AIAA PAPER 95-0995) Copyright

The role of systems simulation in the development of the Boeing 777 twin-engine jetliner Flap/Slat Electronics Unit is described. Discussions and descriptions of the simulation process including the simulation tools, software and hardware involved are provided. On the basis of the lessons learned from developing avionic Line Replaceable Units for the various Boeing airplanes, an efficient avionics development process has evolved using systems simulation as a key tool. Author (Herner)

A95-91492
MIMO H INFINITY CONTROL DESIGN METHOD COMBINED WITH EXACT MODEL MATCHING
T. KIMURA Mitsubishi Heavy Industries Ltd., Japan, M. TAKAHAMA Mitsubishi Heavy Industries Ltd., Japan, E. TOKUDA Mitsubishi Heavy Industries Ltd., Japan, and M. OHNO Mitsubishi Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 20-27 In JAPANESE
Copyright

In this paper, a new design method is proposed to design a robust flight control system (Multiple Input Multiple Output (MIMO) lateral-directional flight control system) which is low-sensitive and robust stable. This method can realize pole-zero assignment by exact model matching and can achieve disturbance zeroing by the H infinity control method (Output Estimation problem). Author (Herner)

A95-91493
A GUST ALLEVIATION METHOD BY THE RESPONSE FEEDBACK
YUKICH TSUKANO National Aerospace Lab., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 32-35 In JAPANESE
Copyright

This paper describes flight test results of a gust alleviation control system in which airspeed and angle of attack are feedback to the elevator and direct lift control (DLC) flap. This shows significant reduction in attitude and vertical acceleration response to turbulence. Author (Herner)

A95-91542
STATUS OF ENHANCED VISION SYSTEM
FUMIO NODA Japan Air Lines Co. Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 354-357 In JAPANESE
Copyright

EVS (Enhanced Vision System) is a cockpit display system for civil aircraft using new sensor technologies. It is being developed mainly in the USA and Europe. It is expected that the EVS will enable pilots to see during adverse weather or night conditions, and will enhance flight safety. This paper represents a study on the current status of EVS. Author (Herner)

A95-91543
GUIDANCE AND CONTROL OF HOPE AND ITS FUTURE TECHNOLOGIES
HIDETO SUZUKI NASDA, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 362-365 In JAPANESE
Copyright

The HOPE (H-2 Orbiting Plane) is a Japanese space transportation vehicle which is planned to be launched in the beginning of 2000's. The Guidance and Control System of HOPE is required to perform navigation, guidance and control during all the flight phases. The key technologies of HOPE Guidance and Control System are the flight algorithm on orbit and re-entry phases, development of on-board equipment including the high performance guidance and control computer, establishment of the design and verification method for the large scale on-board software, and the redundancy management. The present status and future research plans of those technologies are described. Author (Herner)

A95-91559
ON THE UF-104 SYSTEM
JUNICHIRO SUMITA Mitsubishi Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 446-449 In JAPANESE
Copyright

The first Japanese full-scale unmanned autonomous vehicle (UAV). The UF-104 (prototype), is described in brief. The UF-104 program started in 1989 and successfully finished its evaluation tests in 1992. The UF-104 is a radio controlled UAV, with the television monitored by airborne camera at the ground cockpit, and has a 200 nm operational radius, with programmed flight function. In the landing mode, special augmentations in control, and Head-Up Display (HUD) type guidance symbols, etc. are featured. Production is scheduled from 1992. Author (Herner)

A95-91560
ON THE FLIGHT CONTROL SYSTEM FOR UF-104
JUNICHIROU SUMITA Mitsubishi Heavy Industries Ltd., Japan, SHIGERU ASAI Mitsubishi Heavy Industries Ltd., Japan, TATSUAKI KOMATSU Mitsubishi Heavy Industries Ltd., Japan, and HISAKO YASUI Mitsubishi Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 450-453 In JAPANESE
Copyright

A F-104J-based remote control system has been developed for flight control of a full-scale aerial target inclusive of various autonomous modes with full use of the existing aircraft's capabilities to provide the same order of original stability and maneuverability as well. Through consecutive courses of flight tests carried out by Mitsubishi Heavy Industries and Japan Defense Agency, the actual effectiveness of the control system has been successfully confirmed. Author (Herner)

A95-91582
EXACT SOLUTION OF STABILITY MARGIN FOR THE MIMO CONTROL SYSTEM
RYOJI KATAYANGI Mitsubishi Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 588-591 In JAPANESE
Copyright

A new method, Minus Inverse Vector Locus Method, was developed to analyze the stability margin of the multi-input multi-output (MIMO) control system. In this paper, lateral-directional flight control system is discussed as an example system with two inputs. Author (Herner)

A95-91583
EFFECT OF COUPLING TERM ON STABILITY FOR THE TWO INPUT CONTROL SYSTEM
RYOJI KATAYANAGI Mitsubishi Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 592-595 In JAPANESE
Copyright

A lateral-directional flight control system is discussed as an example system with two inputs. Items influencing the stability of the system are the aileron, rudder, and their coupling feedback loops. In this paper, the effect of the coupling term on stability is shown by using a loop transfer function. Author (Herner)

A95-91584
COMPARISON OF THE METHOD OF ANALYZING STABILITY MARGIN BY USING MINUS INVERSE VECTOR LOCUS WITH CLASSICAL METHOD
RYOJI KATAYANAGI Mitsubishi Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 596-599 In JAPANESE
Copyright

As for the classical method for analyzing stability of the system with two inputs such as lateral-directional flight control system, we first calculate the stability margin of a system which is opened in the aileron loop and closed in the rudder loop. Then we calculate the stability of a system which is opened in the rudder loop and closed in the aileron loop. The least stability margin of the two cases is considered as the stability margin of the system. In this paper, comparison of the new method by using the Minus Inverse Vector Locus with the classical method is shown. Author (Herner)

A95-91585
A STUDY OF COMPUTATIONAL DIFFICULTY OF NUMERICAL METHOD IN OPTIMAL CONTROL
MASANORI HARADA and GORO BEPPU *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 600-603 In JAPANESE
Copyright

An iterative numerical solution algorithm has been used for solving optimal control problems. By means of the calculus of variations, thrust and lift, which minimize the cost function, are obtained for flight dynamics problems. But sometimes these controls have inequality constraints. When these inequality constraints have been changed to equality constraints by using dummy controls, some solution by a modified quasilinearization algorithm might converge to an error solution. In this paper, these cases are shown and the reason for the error are analyzed. Author (Herner)

A95-91586
FLIGHT CONTROL SYSTEM DESIGN WITH MULTIPLE DELAY MODEL/MULTIPLE DESIGN POINT APPROACH
YOSHIKAZU MIYAZAWA National Aerospace Lab., Tokyo, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 604-607 In JAPANESE
Copyright

Multiple Delay Model and Multiple Design Point Approach is applied to robust flight control system design. Multiple delay models are used to represent uncertain dynamics, and multiple design points are selected to represent flight condition dependent dynamics. The approach was applied to the 1992 AIAA Control Design Challenge, and the obtained numerical result is discussed. Author (Herner)

A95-91587
MISSILE AUTOPILOT DESIGNS USING FULL STATE FEEDBACK
SADAMU INAISHI Japan Defense Agency, Japan, HIROFUMI EGUCHI Japan Defense Agency, Japan, and TADASHI YAMASITA Kyushu Inst. of Tech., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 620-623 In JAPANESE
Copyright

The aerodynamical model of the yaw-roll channel of missiles with actuators can be regarded as the open system which has the time-invariant structures of uncertainties. The previous paper presented an algorithm seeking the minimum value of an index with respect to the robustness, which determined the state feedback ensuring the robust stability of the closed loop system. But the algorithm is not perfect in the minimization of the closed loop. In this paper, a new algorithm using the penalty method is proposed. It provides a robustly stable yaw-roll missile autopilot, restricting the range for seeking the minimum value of the index. It is shown that the minimum value depends only on the assigned eigenvalues. Author (Herner)

A95-91588
ANALYSIS OF AN MLS AUTOMATIC LANDING CONTROL LAW FOR THE NAL EXPERIMENTAL RESEARCH AIRCRAFT D0-228. 2: CURVED APPROACH AND LANDING
TADAO UCHIDA National Aerospace Lab., Japan, TOSHIHO SAKAI National Aerospace Lab., Japan, KOKI HOZUMI National Aerospace Lab., Japan, TOSHIHARU INAGAKI National Aerospace Lab., Japan, KAZUTOSHI ISHIKAWA National Aerospace Lab., Japan, and KAZUYA MASUI National Aerospace Lab., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 624-627 In JAPANESE
Copyright

The paper presents a preliminary design of an automatic landing control law using microwave landing system (MLS) for the National Aerospace Laboratory (NAL) experimental research aircraft D0-228. The control laws for curved approach path tracking have been finally evaluated by a digital flight simulation with turbulence. Author (Herner)

A95-91696
PITOT/STATIC LEAK TESTING
J. A. CURLEY 1991 3 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 9: Future Aerodynamic Concepts & Equip.)
(CONGRESS PAPER C428-9-035; HTN-95-21127) Copyright

However advanced the cockpit instrumentation in aircraft become, a need for pitot/static leak testing and fault finding remains. Testing can produce more problems than it solves by the operator making mistakes. New test equipment which is safe to use will be described which protects both aircraft and test gear. Author (Herner)

A95-91710
GAS PATH DEBRIS MONITORING
C. E. FISHER Stewart Hughes Ltd, UK 1991 4 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 15: Propulsion 1 Wear Detection) Research sponsored by the UK Ministry of Defence
(CONGRESS PAPER C428-15-031; HTN-95-21141) Copyright

A technique for gas path debris monitoring in gas turbine and jet engines is being developed by Stewart Hughes Limited. Two implementations of the technique enable monitoring of intake debris using the Ingested Debris Monitoring System (IDMS), and engine generated debris using the Engine Distress Monitoring System (EDMS). This paper describes the technology and flight trials of both systems which are currently underway. Author (Herner)

A95-91712
AIRCRAFT GEAR TRAIN DIAGNOSTICS USING THE IRREGULAR ROTATION OF THE EXTENAL SHAFTS
E. B. VULGAKOV, V. V. GOLOVANOV, and A. V. KLIMOV 1991 9 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 15: Propulsion 1 Wear Detection)
(CONGRESS PAPER C428-15-097; HTN-95-21143) Copyright

A method of diagnosing faults in gearboxes is developed, based on measurements of transmission error. The digital processor and software currently developed can handle up to six stages of reduction with no restriction on tooth numbers. The transmission error is evaluated by the primary pulse angular displacement transducers permanently built into the gearbox or temporarily fitted. The software allow manufacturing errors, incipient failure and gear faults in service (pitting, seizing, incipient cracks, etc.) to be determined. The monitoring system is described and results related to manufacturing errors, pitting and cracking are presented. Author (Herner)

A95-91728
AN EXAMPLE OF AIRBORNE VIBRATION MONITORING IMPROVING FLIGHT SAFETY IN THE SOLOVIEV D-30-KU ENGINE
R. W. GREAVES and R. A. ROGALEWICZ 1991 4 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 21: Propulsion 2 Diagnostics in Dev.)
(CONGRESS PAPER C428-21-141; HTN-95-21159) Copyright

In-flight vibration monitoring of engines has become routine since the introduction of FAR 25.1305 (d) (3) in 1974. Modern systems have enhanced diagnostic capability and may be designed to specifically detect known engine problems, as well as fulfilling their primary purpose of detecting rotor unbalance. A case study is presented concerning the Soloviev D-30-KU engine. Author (Herner)

N95-28691 Air Force Inst. of Tech., Wright-Patterson AFB, OH.
THREE-D WEATHER DISPLAYS FOR AIRCRAFT COCKPITS M.S. Thesis
BRADLEY S. BOYER Dec. 1994 62 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A289759; AFIT/CI/CIA-94-166) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The purpose of this study was to examine the effects of dimensionality and rotating frame of reference in a weather avoidance task. Forty student pilots, performed a 3-D route planning task to navigate around weather formations and arrive at a target within an airspace. The subjects were randomly blocked into four groups, each of which used all four of the display types (3-D rotating, 3-D fixed, 2-D rotating, and 2-D fixed) in varying orders. The subjects performed ten trials for each display type. The results indicated that the 2-D and rotating displays supported navigation through a shorter radial distance, and the 2-D displays also resulted in faster weather planning times. This additional distance and time is attributed to the ambiguity within the 3-D displays. There was no significant difference found between the displays in terms of vertical distance traveled, penetrations of the weather formations, number of vectors created, or the evaluation of situational awareness. DTIC

N95-28692 Air Force Inst. of Tech., Wright-Patterson AFB, OH.
CONCEPTUAL DESIGN OF A MAP INTERACTIVE SYSTEM FOR MILITARY AIRCRAFT COCKPITS M.S. Thesis
CRAIG J. WENZ Dec. 1994 103 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A289760; AFIT/CI/CIA-94-158) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

As the complexity and sophistication of military aviation operations rise, the effective interaction and display of map information becomes increasingly important. The purpose of this thesis is to provide a background and directions for those developing new technology in the area of air navigation and to propose a conceptual design of a Map Interactive System (MIS) for military aircraft cockpits. The MIS is an air navigation system that will provide pilots with map displays both on the ground and in the cockpit. Map displays will allow a pilot to view the surrounding environment along the desired route of travel using multiple perspectives. The system will be designed so a pilot may interact with the display, and send and receive vital information while in flight. It will be an amalgamation of current and future technology. The primary purpose of the MIS is to verify a pilot's location and lead him/her to the mission target. DTIC

N95-29123* Tica Technologies, Inc., Cambridge, MA.
OPTIMIZING COCKPIT DISPLAY CONFIGURATIONS WITH A GENETIC ALGORITHM SYSTEM Final Report, 1 Jun. - 30 Nov. 1994
LAWRENCE DAVIS, BETSY CONSTANTINE, STUART SHIEBER, JOE MARKS, and REBECCA HWA 1 Dec. 1994 134 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract(s)/Grant(s): NAS2-14052)
(AD-A289799) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

Our Phase I work resulted in a software prototype for MFD page organization, a technique for translating MFD page organizations into graph partitioning problems, and a genetic algorithm for carrying out the graph partitioning. We apply our system to a scenario taken from the Comanche attack helicopter task analysis. The system outperforms other published algorithms for graph partitioning. DTIC

N95-29950# Boeing Defense and Space Group, Seattle, WA.
INVESTIGATION AND CHARACTERIZATION OF SEU EFFECTS AND HARDENING STRATEGIES IN AVIONICS Technical Report, 1 Oct. 1990 - 30 Sep. 1992
ALLEN H. TABER and EUGENE NORMAND 1 Feb. 1995 93 p
Prepared in cooperation with Loral Federal Systems
(Contract(s)/Grant(s): DNA-MIPR-92-501)
(AD-A291058; DNA-TR-94-123) Avail: CASI HC A05/MF A01

Data from military/experimental flights and laboratory testing indicate that typical non-radiation-hardened 64k and 256k static random access memories (SRAM's) can experience a significant soft upset rate at aircraft altitudes due to energetic neutrons created by cosmic ray interactions in the atmosphere. It is suggested that error detection and correction (EDAC) circuitry be considered for all new avionics designs containing large amounts of semiconductor memory. DTIC

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AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A95-87404
INFLUENCE OF THE FLIGHT TRAJECTORY ON THE EXHAUST GAS COMPOSITION OF A H2-FUELED AIR-BREATHING RAMJET ENGINE
P. MUEHLECK Institute for Propulsion Technology, Koln, Germany, H. SCHUETZ Institute for Propulsion Technology, Koln, Germany, and F. KREMER Institute for Propulsion Technology, Koln, Germany *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 427-437
Copyright

Starting from performance calculations for a generic ramjet configuration, a closer look is taken at the physical phenomena in the combustion chamber and the exhaust nozzle. The flow and the finite rate reaction kinetics are examined using a Navier-Stokes code. The results are discussed with emphasis on the exhaust gas composition variation along the flight trajectory. Author (Herner)

A95-87405
MODELING OF PLUME CHEMISTRY OF HIGH FLYING AIRCRAFT WITH H2 COMBUSTION ENGINES
G. WEIBRING Institute for Physical Chemistry & Electrochemistry, Hannover, Germany and R. ZELLNER Institute for Physical Chemistry & Electrochemistry, Hannover, Germany In Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 439-448
Copyright

Emissions from hydrogen fueled aircraft engines include large concentrations of radicals such as NO, OH, O and H. In the present paper, we describe the result of modeling studies in which the evolution of the radical chemistry in an expanding and cooling plume for three different mixing velocities is evaluated. The simulations were made for hydrogen combustion engines at an altitude of 26 km. For the fastest mixing conditions, the radical concentrations decrease only because of dilution with the ambient air, since the time for chemical reaction is too short. With lower mixing velocities, however, larger chemical conversions were determined. For the slowest mixing conditions the unburned hydrogen is converted into water. As a consequence the radicals O and OH increase considerably around 1400K. The only exception being NO, for which no chemical change during the expansion is found. The concentrations of the reservoir molecules like H2O2, N2O5 or HNO3 have been calculated to remain relatively small. Author (Herner)

A95-87410* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THRUST MODELING FOR HYPERSONIC ENGINES
D. W. RIGGINS University of Missouri-Rolla, Rolla, MO, US and C. R. MCCLINTON NASA. Langley Research Center, Hampton, VA, US 1995 11 p. AIAA, International Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, April 3-7, 1995
(Contract(s)/Grant(s): NAG1-1189)
(AIAA PAPER 95-6081; HTN-95-92594) Copyright

Expressions for the thrust losses of a scramjet engine are developed in terms of irreversible entropy increases and the degree of incomplete combustion. A method is developed which allows the calculation of the lost vehicle thrust due to different loss mechanisms within a given flow-field. This analysis demonstrates clearly the trade-off between mixing enhancement and resultant increased flow losses in scramjet combustors. An engine effectiveness parameter is defined in terms of thrust loss. Exergy and the thrust-potential method are related and compared. Author (Herner)

A95-87413
TESTING THE HYPERSONIC TECHNOLOGY DEMONSTRATION NOZZLE: RESULTS FROM THE TEST CAMPAIGN 1993/94
R. LEDERER MTU Motoren- und Turbinen-Union Muenchen, Munich, Germany and W. KRUEGER MTU Motoren- und Turbinen-Union Muenchen, Munich, Germany 1995 6 p. AIAA, International Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, April 3-7, 1995 Research sponsored by the German Ministry of Research and Technology
(AIAA PAPER 95-6084; HTN-95-92597) Copyright

One key component of all hypersonic air-breathing engines is the nozzle exhaust system. However, before such engines become reality, a degree of progress must be made in aerodynamic, structural, cooling and installation aspects. This makes the nozzle a very challenging and interdisciplinary component. In order to tackle these topics and to demonstrate enabling technologies, especially cooling, sealing and structural aspects, the so called Technology Demonstration Nozzle (TDN) has been designed, fabricated and tested. In this paper the associated effort is highlighted. Test results in the areas internal flow (thrust), cooling system as well as pressure and temperature loading are presented and explained, and compared with predictions and computational fluid dynamics (CFD) results. Additionally, applied measurement techniques are addressed. Finally, a preview is given of some forth-coming activities.
Author (Herner)

A95-87466
FLYOVER NOISE REDUCTION OF PISTON-ENGINE PROPELLER AEROPLANES USING AN ACTIVE NOISE CONTROL TECHNIQUE
MICHAEL K. KALLERGIS and KONSTANTIN M. KALLERGIS (ISSN 0148-7191) 1993 17 p. SAE, General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, KS, May 18-20, 1993
(SAE PAPER 931218; HTN-95-00877) Copyright

Certain propeller driven aeroplanes are equipped with piston engines whose fundamental 'firing'-frequency coincides with the rotational frequency of the propeller source (propeller) and a secondary anti-noise source (engine exhaust), an active noise control (ANC) technique can be applied. The far field noise of both the propeller and the engine exhaust is characterized by periodic sound pressure fluctuations; by generating a suitable phase shift between these two periodic sound-fields, a destructive interference may be attained, resulting in a reduced overall noise level immission on the ground. Technically, this is achieved by (1) adjusting the spatial distance between the exhaust orifice and the propeller and (2) an appropriate azimuthal positioning of the propeller on the crankshaft of the engine. Author (Herner)

A95-88002

SCRAMJET COMBUSTOR DESIGN IN FRANCE

MARC BOUCHEZ Aerospatial Missiles, Bourges, France, NICOLE MONTMAYEUR Aerospatial Missiles, Chatillon, France, CHRISTOPHE LEBOUCHER SNECMA, Villaroche, France, and MICHEL SOUCHET SNECMA, Villaroche, France 1995 7 p. AIAA International Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, April 3-7, 1995

(AIAA PAPER 95-6094; HTN-95-92641) Copyright

In the scope of PREPHA program AEROSPATIALE, ONERA, SEP, SNECMA work together on research about supersonic combustion and hydrogen-fueled scramjet technology. AEROSPATIALE has designed and built a steel scramjet model called 'CHAMOIS' (French acronym for Modular CHAmber for Optimization of Scramjet Injection) for ground testing at Mach 6 conditions in Bourges and Modane French test facilities. Its rectangular entrance area is about 0,05 m2. This combustor is equipped with wall measurement systems and optical means: this allows French specialists to estimate the combustor efficiency, to compare different shapes and injection systems, to understand the real size scramjet phenomena and to validate the numerical tools. Experimental runs of scramjet combustors had been planned at Mach numbers 6 and 8 in ONERA-Modane. For that purpose, SNECMA is in charge of the design of a heat sink cooled copper model taking into account advanced injection system (involving also Aerospatiale, ONERA and SEP) and combustor shape in order to provide optimum performance for both Mach numbers. Flow field combustor design parameters are estimated by analytical codes, and 2D and 3D reactive Navier-Stokes computations are performed both by structured-mesh codes (such as MATHILDA) and un-structured-mesh codes (such as NATUR). Author (Herner)

A95-88003

CONCEPTUAL STUDIES OF HIGH SPEED COMBUSTORS FOR MIXING ENHANCEMENT MECHANISMS

BALU SEKAR Wright Laboratory, Wright-Patterson AFB, OH, US 1995 11 p. AIAA International Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, April 3-7, 1995

(AIAA PAPER 95-6095; HTN-95-92642) Copyright

This study compares University of Virginia's experimental results for air to air parallel mixing from a circular jet located in the base of a swept ramp, with numerical results derived from the three-dimensional, Navier-Stokes, finite volume, upwind code GASP (Generalized Aerodynamic Simulation Program). Using the circular jet shape as the basis, for the same injected air massflow and approaching freestream conditions, various jet shapes are modeled as a rectangle, triangle, a row of vertical slots, a row of horizontal slots, inclined wall jet and a combination of parallel and inclined jets. The results obtained from this numerical simulation include mixing efficiency, static pressure, and total pressure. Comparisons between various fuel injector concepts indicate the relative differences in the predicted preformance of the combustor from a mixing point of view. The results indicate walls jets, even though they mix better than parallel mixing mechanisms from any of the fuel-split arrangements, still suffer from increased total pressure losses. In general, any fuel injection arrangements, to effectively include any large scale vortical motion of the approaching stream seem to increase the efficiency of the mixing with a lesser total pressure loss than wall jet mechanisms. It appears there is a trade off between increased mixing and increased total pressure loss. Author (Herner)

A95-88004

INJECTION STUDIES IN THE FRENCH HYPERSONIC TECHNOLOGY PROGRAM

D. SCHERRER ONERA, Chatillon, France, O. DESSORNES ONERA, Chatillon, France, O. FERRANDON SEP, Vernon, France, and N. MONTMAYEUR AEROSPATIALE Missiles, Les Gatines, France 1995 14 p. AIAA International Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, April 3-7, 1995

(AIAA PAPER 95-6096; HTN-95-92643) Copyright

During the first year of the French hypersonic program PREPHA, various concepts of scramjet injector struts had been studied. Two concepts had been defined to be tested individually at conditions simulating Mach 6. Tests results of these two concepts are presented and compared with three-dimensional calculations. The first concept led to a stable supersonic combustion regime at all equivalence ratios. With the second concept, designed to optimize mixing efficiency, some difficulties were encountered, relative to ignition delay (at low equivalence ratio) and to precombustion shock train occurrence (at high equivalence ratio). In parallel, basic experiments relative to jet penetration and ignition were performed: they provide an extended data base which can be used to support strut injectors design. From all these studies, a strut injector concept has been chosen for the injection system of the PREPHA test scramjet CHAMOIS. Author (Herner)

A95-88005* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

NUMERICAL STUDY OF CONTAMINANT EFFECTS ON COMBUSTION OF HYDROGEN, ETHANE, AND METHANE IN AIR

H. T. LAI NYMA, Inc., Brook Park, OH, US and S. R. THOMAS NASA. Lewis Research Center, Cleveland, OH, US 1995 4 p. AIAA International Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, April 3-7, 1995

(AIAA PAPER 95-6097; HTN-95-92644) Copyright

A numerical study was performed to assess the effects of vitiated air on the chemical kinetics of hydrogen, ethane, and methane combustion with air. A series of calculations in static reacting systems was performed, where the initial temperature was specified and reactions occurred at constant pressure. Three different types of test flow contaminants were considered: NO, H2O, and a combination of H2O and CO2. These contaminants are present in the test flows of facilities used for hypersonic propulsion testing. The results were computed using a detailed reaction mechanism and are presented in terms of ignition and reaction times. Calculations were made for a wide range of contaminant concentrations, temperatures and pressures. The results indicate a pronounced kinetic effect over a range of temperatures, especially with NO contamination and, to a lesser degree, with H2O contamination. In all cases studied, CO2 remained kinetically inert, but had a thermodynamically effect on results by acting as a third body. The largest effect is observed with combustion using hydrogen fuel, less effect is seen with combustion of ethane, and little effect of contaminants is shown with methane combustion. Author (Herner)

A95-89195

AUXILIARY POWER UNIT EVOLUTION: MEETING TOMORROW'S CHALLENGES

GEOFFREY D. WOODHOUSE Allied Signal Auxiliary Power, US (ISSN 0148-7191) 1993 8 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993

(SAE PAPER 932541; HTN-95-A1475) Copyright

In a little over thirty-five years the Auxiliary Power Unit (APU) has evolved from a simple onboard source of starting energy to a flight-essential component for today's commercial transports engaged in Extended Range Twin Engine Operations (ETOPS). In the course of this transition, the APU has progressed from a simple turbomachine to one employing comparable technologies to similarly sized propulsion engines. Reliability, troubleshooting, maintainability, and similar characteristics critical to economical airline operation have necessitated progressively increased sophistication in the design and tesing of APUs. Peculiar requirements to APUs, such as totally dependable starting at 40,000 feet and above when cold soaked to -65 F exceed the challenges of most propulsion engine systems. This paper addresses the issues facing the APU designer, with particular reference to reliability and maintainability characteristics, major drivers for current APU designs. The paper will highlight some of the special design considerations imposed by the unique environmental and installation demands applicable to today's APUs. Author (Herner)

A95-90056
SYSTEM DESIGN CONSIDERATIONS FOR AN APU STARTER-GENERATOR
THOMAS S. LATOS Sundstrand Aerospace, US and MALCOLM J. MCARTHUR Sundstrand Power Systems, US (ISSN 0148-7191) 1993 7 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932559; HTN-95-A1481) Copyright

This paper examines the utility of an auxiliary power unit (APU) starter-generator system consisting of the 400 Hz APU generator and a start converter. The reliability of the APU start system indicates improvement because of mechanical simplification and coordination of the APU acceleration and the APU engine controller, but results are difficult to quantify. Interface with the electrical power generating system (EPGS) is required since the APU generator is a shared LRU. Author (Herner)

A95-90057
A SWITCHED RELUCTANCE MACHINE ROTOR POSITION ESTIMATOR: A NEURAL NETWORK APPLICATION
JENIFER M. SHANNON Naval Air Warfare Center, Warminster, PA, US (ISSN 0148-7191) 1993 8 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932560; HTN-95-A1482) Copyright

A method of estimating the rotor position of a switched reluctance machine without the need for a rotor-mounted position sensor has been developed. This method takes advantage of the information derived from known phase voltage and current waveforms. The information is fed as the inputs to a neural network, which after being trained, can correctly map the rotor position to its output. The most accurate mapping results were obtained using a Cerebellar Model Articulation Controller (CMAC) neural network. The performance of the neural network has been tested with measured waveforms from a three phase 120 HP switched reluctance motor. It successfully maps the rotor position with an average root mean square error of one tenth of a mechanical degree. Author (Herner)

A95-90059
ELECTRICAL POWER SYSTEM UPGRADE METHODOLOGY FOR IN-SERVICE AIRCRAFT
JAMES A. GLADFELDER Lockheed Aeronautical Systems Co., US (ISSN 0148-7191) 1993 10 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932562; HTN-95-A1484) Copyright

With today's trend toward reduced spending for new weapons systems comes the desire to extend the useful life of existing airframes, and to upgrade aircraft and mission avionics suites to meet the existing and future threat. While upgrades may include structural and avionics improvements, the electric power system usually remains unchanged; often becoming the major cause of aborted missions and aircraft down-time. A specific need exists to identify a systematic approach for developing improvements to existing electric power systems. This paper explores this problem and develops a methodology which could be applied to its solution. Author (Herner)

A95-90083
HIGH BYPASS SEPARATE FLOW EXHAUST SYSTEM IMPROVED THRUST EFFICIENCY BY MODIFYING THE AFT CENTERBODY
BOB BABBITT GE Aircraft Engines, US (ISSN 0148-7191) 1993 10 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993
(SAE PAPER 932622; HTN-95-A1508) Copyright

Scale model data indicated a performance dip in nozzle thrust efficiency at the cruise design conditions for a high bypass separate flow derivative exhaust system. A performance improvement program was implemented to determine the cause of the reduction in thrust efficiency and to identify viable redesigns. Data analysis indicated the performance loss to be a result of high Mach number fan and core exhaust interactions adversely affecting the pressure force on the exhaust system centerbody. Scale model testing confirmed the cause of performance loss and demonstrated that modifying the aft centerbody to reduce the plume Mach number recovers the loss in exhaust system thrust efficiency. Author (Herner)

A95-90440* National Aeronautics and Space Administration, Washington, DC.
CHARACTERIZATION OF A HOT-FILM PROBE FOR HYPERSONIC FLOW
M. SHEPLAK Syracuse University, Syracuse, New York, US, E. SPINA Syracuse University, Syracuse, New York, US, and C. MCGINLEY NASA Langley Research Center, Hampton, Virginia, US 1995 10 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(Contract(s)/Grant(s): NAGW-3713; NGT-51171)
(AIAA PAPER 95-6110; HTN-95-B0359) Copyright

The critical issues concerning the application of constant-temperature hot-film anemometry to hypersonic flow are reviewed and extended. Mass-flux static calibrations were conducted in a Mach 10 helium flow, while mass-flux and total-temperature static calibrations were made in a Mach 6 air flow. In addition, comparative hot-film/hot-wire turbulence measurements were made in a Mach 11 helium boundary layer to provide insight into the dynamic response of the hot film. The measurements indicate that substrate conduction 'losses' dominate the static response of the hot-film probe, thus resulting in poor sensitivity to mass-flux and total temperature. Furthermore, it has been found that it is not possible to isolate mass-flux fluctuations at high overheat ratios for the current hot-film design. Thus, the sapphire-substrate hot-film anemometer is a robust, high-bandwidth instrument limited to qualitative transition and turbulence measurements. Finally, the extension of this technique to providing quantitative information is dependent upon the development of lower thermal-conductivity substrate materials. Author (Herner)

A95-90442
TEMPERATURE DIAGNOSTICS IN THE HYPERSONIC FLOW REGIME: AN APPLICATION TO DEVELOP A STAGNATION TEMPERATURE PROBE
O. PIN I.M.P. C.N.R.S., Odeillo, France, J. BADIE I.M.P. C.N.R.S., Odeillo, France, G. OLALDE I.M.P. C.N.R.S., Odeillo, France, and M. CLEMENT S.E.P., Vernon, France 1995 7 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(AIAA PAPER 95-6114; HTN-95-B0361) Copyright

The objective of this study is to develop an intrusive probe to measure the stagnation temperature in the range 2000-3500 K for supersonic combustion flow. To approach this complex problem, we use a thermal plasma flow of N_2 in which the velocity is such that the static temperature is approximately equal to the stagnation temperature. We first developed a spectroscopic method to measure with high accuracy the temperature in the plasma flow. The method is based on the analysis of the molecular band of CN at 388.3 nm and will then be used to calibrate the intrusive probe. This approach permits the following developments: (1) to be able to select different concepts of stagnation temperature probes, (2) to investigate their behavior under dynamic conditions, (3) to develop a method to calibrate these probes with spectroscopic techniques. Furthermore, this study may permit one to obtain the scientific information necessary to design and develop a thermo-optical probe which works in the hypersonic flow regime. Author (revised by Herner)

A95-90450

THE DCAF: A HIGH-ENTHALPY LONG-DURATION, DIRECT-CONNECT SCRAMJET TEST FACILITY

M. THOMPSON Johns Hopkins University, Laurel, Maryland, US and P. JANDOLFINI Johns Hopkins University, Laurel, Maryland, US 1995 9 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995 Research sponsored by National Aerospace Plane Joint Program Office
(AIAA PAPER 95-6130; HTN-95-B0369) Copyright

With funding from the National Aerospace Plane (NASP) program, the Johns Hopkins University Applied Physics Laboratory and The National Aeronautics and Space Administration Ames Research Center have established the Direct-Connect Arc Facility (DCAF), a high-enthalpy, long-duration tunnel used to evaluate the performance of high-speed cramjet combustor configurations. The DCAF uses a 100-MW electric arc heater to provide approximately 10 lbm/s of air at enthalpies simulating Mach 9 to 12 flight to a generic scramjet combustor. Unlike the short-duration tests in pulse facilities, DCAF tests can have run times that are orders of magnitude greater than those necessary to establish supersonic combustive flow inside a large-scale combustor. This paper discusses innovative experimental measurements unique to the DCAF and describes the experimental setup and test technique rationale. Measurements to be discussed include those required for the successful application of steam calorimetry and cycle analyses in determining fuel injector performance. Test conditions produced by the DCAF are presented and compared with those expected in flight to quantify the capabilities demonstrated to date. Author (Herner)

A95-90456

CHEMICALLY REACTING NON-EQUILIBRIUM BOUNDARY LAYERS IN AIR BREATHING PROPULSION SYSTEMS

J. SOMMERHAEUSER Technical University of Aachen, Aachen, Germany, J. BUSSMANN Technical University of Aachen, Aachen, Germany, and W. KOSCHEL Technical University of Aachen, Aachen, Germany 1995 10 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995 Research sponsored by the Deutsche Forschungsgemeinschaft
(AIAA PAPER 95-6139; HTN-95-B0375) Copyright

A numerical method for the computation of laminar non-equilibrium boundary layers with arbitrary fluid composition in air breathing propulsion systems is presented. The computation is based on the solution of the first order boundary layer equations, respecting chemical non-equilibrium phenomena. Therefore, species conservation equations and additional terms in the energy equation are introduced. The determination process of the transport properties and the thermodynamic values are discussed. The implemented finite-difference scheme will be briefly described. Finally, some results of the simulation of multi-component fluids near catalytic and non-catalytic walls are presented and discussed. Futheron results of an expanding nozzle flow in air breathing hypersonic proplusion systems are shown, whereby a special interest is laid upon the influence of the temperature boundary condition. Author (Herner)

A95-90462

AN ASSESSMENT OF GROUND-TEST FACILITY CAPABILITIES FOR MEASUREMENT OF HYPERVELOCITY SCRAMJET PERFORMANCE

R. BAKOS, W. CHINITZ, and J. ERDOS 1995 13 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(AIAA PAPER 95-6148; HTN-95-B0381) Copyright

The reliability of scramjet performance data obtained in existing ground-test facilities may be limited by contamination of the test air by dissociation products and non-ideal simulation of the primitive flow variables at the scramjet entrance. Test results are reviewed in which the level of atomic oxygen was varied over a wide range and no significant difference in scramjet nozzle thrust was measured. Analysis is then presented to generalize this result to test conditions that duplicate, as closely as possible with demonstrated tunnel technology, scramjet operating conditions over the sub-orbital regime. Predictions are made of the effect of contamination on net thrust which is a more sensitive measure of variations in combustor performance than nozzle thrust. It is shown that the stagnation pressure limitations of existing facilities depress the performance that can be measured relative to flight for speeds above about Mach 13. A 500 second impulse decrement is predicted at Mach 20, while the effect of dissociation contamination is to enhance the performance by approximately 100 second throughout the regime. Author (revised by Herner)

A95-90470

SECONDARY POWER SYSTEM STUDY FOR THE HYTEX RA3 FLIGHT TEST VEHICLE

T. SATMARK Volvo Aero Corporation, Trollhattan, Sweden, H. STREIFINGER MTU Motoren- und Turbinen- Union, Munchen, Germany, J. KRETSCHMER Daimler-Benz Aerospace AG, Munchen, Germany, and G. MOSER Daimler-Benz Aerospace AG, Munchen, Germany 1995 11 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995 Research sponsored by the German Ministry of Research and Technology
(AIAA PAPER 95-6158; HTN-95-B0389) Copyright

In Europe, one of the suggested space transportation concepts is the German SANGER, which is the reference concept in German Hypersonics Technology Program. In the German Hypersonics Technology Program the need for a hypersonic flight test vehicle has been identified. A vehicle called Hytex RA3 has been studied during 1993/94 as a potential flight test vehicle. MTU and DASA are responsible for the propulsion studies of the Hytex RA3 and Volvo Aero Corporation has led a team responsible for the Secondary Power System (SPS). The paper describes some major aspects of the SPS studies. The main requirements and functions are outlined, together with typical data describing similarities and differences with the SPS for a full scale hypersonic vehicle. Some alternative SPS concepts to meet the requirements are described. The focus is on possible power generation systems and their integration with the cooling system. Criteria are discussed for the selection of a SPS for a flight test vehicle. Performance criteria such as fuel consumption and weight of the SPS hardware have to be balanced with development costs, safety, reliability and the need to demonstrate technologies identified as necessary for a full scale hypersonic vehicle. SPS concepts on a scale from simple and robust, but heavy battery powered systems, to complex systems using multiple turbomachines and heat exchangers in order to optimise weight and fuel consumption, are presented in the paper. Author (revised by Herner)

A95-91495

TWENTY-FIRST CENTURY COMMERCIAL TRANSPORT ENGINES

HOWARD Y. STRYKER Pratt and Whitney, United Technologies Corp., East Hartford, CT, US *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 44-46
Copyright

The paper reviews commercial propulsion fuel consumption, noise and reliability improvements over the past thirty years, and shows projection of further improvements expected with the next generation of turbofan engines and the Advanced Ducted Prop, or ADP. The next breakthrough in subsonic propulsion, the ADP, offers the fundamental propulsive benefit of high bypass ratio, resulting in a significant reduction in fuel consumption and noise. Pratt and Whitney, working with its partners, has initiated an ADP Program which is developing the key enabling technologies, including a fan-drive gearbox, a fan variable pitch mechanism and lightweight, 'slimline' nacelle. Author (Herner)

A95-91502

AERO-ENGINE R&D EFFORTS FOR ENVIRONMENTAL PROTECTION

TEIICHI TAMAKI Ishikawajima-Harima Heavy Industries Co. Ltd.,

Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 76-79 In JAPANESE
Copyright

Recently global environmental sustainability has become a worldwide concern because of global warming, acidification of the environment and ozone layer destruction. This paper introduces research and development efforts for environmental protection. High bypass ratio turbofan engines were adopted and fan jet noise reduction programs were conducted for reduction of the aero-engine noise level. In order to reduce the atmospheric pollution by such gases as CO, UHC, NOX and CO2, new combustion concepts are required. A multi-stage combustor, variable geometry combustor, lean pre-mixed combustor and rich burn/quick quench/lean burn combustor are discussed. Author (Herner)

A95-91637
CONDENSING CYCLE AIR CONDITIONING SYSTEM
GREGORY L. DE FRANCESCO (ISSN 0148-7191) 1993 6 p. SAE, International Conference on Environmental Systems, 23rd, Colorado Springs, CO, July 12-15, 1993
(SAE PAPER 932056; HTN-95-21068) Copyright

This paper describes the latest advancement in air cycle environmental control systems (ECS) for commercial aircraft. The concept, which has been designated the condensing cycle has been selected for use in the 777 and MD-12 air conditioning systems. It incorporates features of the high pressure water separation chilled recirculation systems introduced in the 1980's on the Boeing 757 and 767, and A320, and numerous pressurized commuter aircraft. Additional benefits are realized in the areas of cycle efficiency, control simplicity, moisture removal performance, and ram drag reduction through the incorporation of a four-wheel (two-stage turbine) air cycle machine. A detailed description of the cycle is presented in this paper as well as details of the advantages of this approach relative to three-wheel air cycle machine chilled recirculation systems. Author (Herner)

A95-91638
WHAT'S NEXT IN COMMERCIAL AIRCRAFT ENVIRONMENTAL CONTROL SYSTEMS?
KIM LINNETT and RONALD CRABTREE (ISSN 0148-7191) 1993 15 p. SAE, International Conference on Environmental Systems, 23rd, Colorado Springs, CO, July 12-15, 1993
(SAE PAPER 932057; HTN-95-21069) Copyright

Before considering the future of aircraft environmental control systems (ECS's), a review of the relatively short history of this field would be valuable in understanding the present situation. Therefore, this paper notes many of the significant developments in commercial aircraft air-cycle refrigeration and in cabin environmental control. The evolution leading to the great variety of air-cycle systems now in production, or under development, is discussed along with a generic comparison of the merits of the various system types and some reasons for their selection. Constraints on air conditioning system development imposed by the airline operators, aircraft manufacturers, and regulatory agencies are touched upon as significant to charting the future of air conditioning system design. Finally, several directions that could be taken in future design are briefly commented upon. Author (Herner)

N95-28908 Wright Lab., Wright-Patterson AFB, OH.
RECIRCULATING CAVITY CASING TREATMENT FAILURE Final Report, Apr. 1993 - Feb. 1994
PAUL T. KERNEY Aug. 1994 22 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A289330; WL-TR-94-2092) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

As part of the Augmented Damping of Low Aspect Ratio Fans (ADLARF) program at the Compressor Research Facility (CRF), the Recirculating Cavity Casing Treatment was in test operation. The casing treatment was made of 6061-T6 aluminum alloy and was specially instrumented for the exploration of stall margin, performance data, and thermal effects. In addition to obtaining stall margin data, this casing treatment was part of a detailed test program to study the effects of five different casing treatments. After thermal cycling the casing treatment between ambient temperature and 650 F, the casing treatment failed after seven hours of test time. The casing treatment was removed and a failure analysis was performed. This paper will summarize the study findings and conclude with recommended actions. DTIC

N95-29115*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LEADING EDGE FILM COOLING EFFECTS ON TURBINE BLADE HEAT TRANSFER
VIJAY K. GARG (AYT Corp., Brook Park, OH.) and RAYMOND E. GAUGLER Jun. 1995 19 p Presented at the 40th Gas Turbine and Aeroengine Congress and Exposition, Houston, TX, 5-8 Jun. 1995; sponsored by ASME Original contains color illustrations
(Contract(s)/Grant(s): RTOP 505-62-52)
(NASA-TM-106955; E-9705; NAS 1.15:106955) Avail: CASI HC A03/MF A01; 3 functional color pages

An existing three dimensional Navier-Stokes code, modified to include film cooling considerations, has been used to study the effect of spanwise pitch of shower-head holes and coolant to mainstream mass flow ratio on the adiabatic effectiveness and heat transfer coefficient on a film-cooled turbine vane. The mainstream is akin to that under real engine conditions with stagnation temperature = 1900 K and stagnation pressure = 3 MPa. It is found that with the coolant to mainstream mass flow ratio fixed, reducing P, the spanwise pitch for shower-head holes, from 7.5 d to 3.0 d, where d is the hole diameter, increases the average effectiveness considerably over the blade surface. However, when P/d= 7.5, increasing the coolant mass flow increases the effectiveness on the pressure surface but reduces it on the suction surface due to coolant jet lift-off. For P/d = 4.5 or 3.0, such an anomaly does not occur within the range of coolant to mainstream mass flow ratios analyzed. In all cases, adiabatic effectiveness and heat transfer coefficient are highly three-dimensional. Author

N95-29244 Massachusetts Inst. of Tech., Cambridge, MA.
MODELING AND CONTROL OF ROTATING STALL IN HIGH SPEED MULTI-STAGE AXIAL COMPRESSORS Ph.D. Thesis
MATTHEW ROGER FEULNER 1994
Avail: Issuing Activity (MIT Libraries, Rm. 14-0551, Cambridge, MA 02139-4307)

Using a two-dimensional, compressible flow representation of axial compressor dynamics, a control-theoretic input-output model is derived which is of general utility in rotating stall and surge active control studies. Geometry of a three stage research compressor is used in this model to perform control configuration studies using operating range extension and mean-square costs in the comparisons. The derivation presented begins with a review of the fluid dynamic model, which is a 2D stage stacking technique that accounts for blade row pressure rise, loss and deviation as well as blade row and inter-blade row compressible flow. This model is extended to include the effects of the upstream and downstream geometry and boundary conditions, then manipulated into a transfer function form that dynamically relates actuator motion to sensor measurements. Transcendental functions in this input-output form are then approximated using rational polynomials. Further manipulations yield an approximate state-space model which is in standard form for studying active control of rotating stall and surge. Specifications on the control system are proposed which are standard restrictions in modern control theory. Cost functions are proposed to compare control configurations. Two control design methods are presented to design the compensators. The linear quadratic-Gaussian optimal control minimizes a mean-square cost function of the perturbations and the control activity. The H(sub infinity) optimal control minimizes the H(sub infinity)-norm related to the specifications. The control design methods are then applied to the geometry of a three stage research compressor. As examples of high current relevance, the transfer functions from an array of jet actuators to

arrays of either static pressure, stagnation pressure, and velocity sensors are examined. It is found that using a jet actuator that reduces the momentum of the flow can be as good as a jet actuator which adds equivalent momentum. It is also found that velocity and stagnation pressure sensors are superior to static pressure sensors.
Dissert. Abstr.

N95-29496# Massachusetts Inst. of Tech., Cambridge, MA. Gas Turbine Lab.
INTELLIGENT TURBINE ENGINES FOR ARMY APPLICATIONS Final Report, 28 Feb. 1994 - 27 Aug. 1994
ALAN H. EPSTEIN Nov. 1994 165 p Workshop held in Cambridge, MA, 21-22 Mar. 1994; sponsored by the US Army Research Office
(Contract(s)/Grant(s): DAAH04-94-G-0038)
(AD-A290532; ARO-3305.1-EG-CF) Avail: CASI HC A08/MF A02
This report documents the proceedings of a workshop on Intelligent Turbine Engines for Army Applications held at the Massachusetts Institute of Technology on March 21-22, 1994. The workshop brought together experts from government, industry, and academia to explore ways in which advanced controls concepts can be used to significantly benefit Army gas turbine engines. Participants discussed Army control related requirements. Emphasis was placed on the integration of active control into helicopter and ground vehicle gas turbines. DTIC

N95-29679 Georgia Inst. of Tech., Atlanta, GA.
MODEL DEVELOPMENT FOR ACTIVE CONTROL OF STALL PHENOMENA IN AIRCRAFT GAS TURBINE ENGINES Ph.D. Thesis
KEVIN MICHAEL EVEKER 1993 210 p
Avail: Univ. Microfilms Order No. DA9415634
This study addresses model development for active control of stall phenomena in aircraft gas turbine engines. The high-frequency nature of these phenomena requires a new approach for modelling aircraft gas turbine engines (and turbomachinery systems in general). Since the models developed using this approach are for use in control design, they must be control-oriented (i.e. suitable for use in control design). An approach for control-oriented high-frequency turbomachinery modelling based on quasi-1D flow equations is developed. The suitability of this approach for developing control-oriented high-frequency turbo machinery models is illustrated by developing models of generic systems of this type which are easily adapted to specific systems. Models are developed in detail for the case of calorically perfect single species gases, and extension of the approach to develop models to the case of thermally perfect multiple species gases is also discussed. Models of specific systems are given to demonstrate the ability of the models to predict 1D stall phenomena and the suitability of these models for use in the design of active control of these 1D phenomena. The specific systems mentioned are an axial compressor rig and a turbojet engine rig for which experimental data is available for use in model development and validation. In addition to the models which predict 1D stall phenomena, use of the approach based on quasi-ID flow equations to model 2D stall phenomena which involve circumferentially varying 1D flow is also discussed. Dissert. Abstr.

N95-29764# Georgia Tech Research Inst., Atlanta, GA.
MEASUREMENTS OF IONS FORMED IN JET ENGINE EXHAUST PLUMES
F. L. EISELE 23 Jun. 1994 20 p
(Contract(s)/Grant(s): F19628-93-K-0018)
(AD-A290940; PL-TR-94-2253; SR-1) Avail: CASI HC A03/MF A01
An atmospheric pressure chemical ionization mass spectrometer was modified to measure either ion or neutral effluents from a jet engine. The instrument was set up behind an F-15 aircraft at Eglin Air Force Base and measured the ions formed in both the positive and negative spectrum. Since the ion concentrations in the jet plume were quite small and measurement times relatively short, most of the measurements performed were of ions artificially produced in the exhaust using a corona ion source. The most obvious change in the ion spectrum after the jet engines were started was the dramatic increase in what appeared to be sulfuric acid. The spectra resulting from these measurements are shown and discussed. DTIC

N95-29934# Wright Research Development Center, Wright-Patterson AFB, OH. Aero Propulsion and Power Lab.
CHARACTERIZATION OF STALL INCEPTION IN HIGH-SPEED SINGLE-STAGE COMPRESSORS Final Report, 1 Aug. - 1 Dec. 1992
KEITH BOYER Dec. 1994 166 p
(Contract(s)/Grant(s): AF PROJ. 2307)
(AD-A291275; WL-TR-93-2058) Avail: CASI HC A08/MF A02
All aircraft gas turbine engines currently compromise compression system performance at some point(s) in their operating envelope to obtain 'adequate' stall margin. This work pursues the concept of active stall control to minimize or eliminate this penalty, thereby improving the performance of any aircraft gas turbine engine.
DTIC

N95-30007*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INLET FLOW TEST CALIBRATION FOR A SMALL AXIAL COMPRESSOR RIG. PART 2: CFD COMPARED WITH EXPERIMENTAL RESULTS
D. P. MILLER and P. S. PRAHST (NYMA, Inc., Brook Park, OH.) Jul. 1995 16 p Presented at the 31st Joint Propulsion Conference and Exhibit, San Diego, CA, 10-12 Jul. 1995; sponsored by AIAA, ASME, SAE, and ASEE
(Contract(s)/Grant(s): RTOP 505-62-10)
(NASA-TM-106999; E-9778; NAS 1.15:106999; AIAA PAPER 95-3037) Avail: CASI HC A03/MF A01
An axial compressor test rig has been designed for the operation of small turbomachines. A flow test was run to calibrate and determine the source and magnitudes of the loss mechanisms in the compressor inlet for a highly loaded two-stage axial compressor test. Several flow conditions and inlet guide vane (IGV) angle settings were established, for which detailed surveys were completed. Boundary layer bleed was also provided along the casing of the inlet behind the support struts and ahead of the IGV. Several computational fluid dynamics (CFD) calculations were made for selected flow conditions established during the test. Good agreement between the CFD and test data were obtained for these test conditions. Author

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A95-87397
TRIM CONDITIONS FOR OPTIMAL FLIGHT PERFORMANCE OF HYPERSONIC AIRCRAFT
M. GERKEN Technical University of Braunschweig, Braunschweig, Germany, T. KUEPPER Technical University of Braunschweig, Braunschweig, Germany, and G. REICHERT Technical University of Braunschweig, Braunschweig, Germany In Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 335-344
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Several trim conditions for the steady cruise flight of a winged two-stage hypersonic aircraft are investigated. The influence of the thrust on the balance of moments is considered. The required thrust will be minimized for each trim condition by application of Optimal Control. Possibilities for thrust reduction of the extended trim conditions with thrust vectored propulsion and trim tank system are

demonstrated. The influence of flap trimming on the total drag and aerodynamic control potential is shown. Author (Herner)

A95-87398
HANDLING QUALITIES OF HYPERSONIC AIRCRAFT AND RELATED CONTROL REQUIREMENTS
R. BROCKHAUS Technical University of Braunschweig, Braunschweig, Germany *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 345-356
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The hypersonic aircraft is one principal link of reusable orbital transport system. After a conventional take-off, it will bring the space orbiter to its launching condition and then turn back with a more or less conventional approach and landing. Because of the flight regime up to Mach 7 or 8, this launching vehicle will be a slender wing aircraft, more similar to Concorde, B 70 or SR 71, than to present transports. Large, slender aircraft of this type have a special geometry and mass distribution and unconventional aerodynamic properties, which lead to unusual handling qualities, especially in low speed and high angle of attack flight. Their control configuration, characterized by elevons at the trailing edge of the delta wing and the absence of high lift devices, is a further source of poor handling qualities and trim problems. Especially with such projects as ELAC and Sanger II the high interference between the engine flow and the aerodynamics of wing and aft-body produce further flying quality problems. The following analysis of handling qualities of supersonic and hypersonic aircraft is restricted to the low speed flight regime, especially to the approach and landing phase. This is done because on one hand this is the area where existing information and experience can be extrapolated to hypersonic vehicles, and on the other hand, as has been stated by the commander of the fourth Shuttle Orbiter flight, because 'the importance of flying qualities is inversely proportional to altitude'. From this analysis and from the available information on Concorde and Shuttle Orbiter control systems, the control requirements for hypersonic aircraft are extrapolated. A comparison between modern flight control systems and new developments in the field shows the principal lines of necessary research. Author (Herner)

A95-89636
AIRCRAFT CONTROLLER SYNTHESIS BY SOLVING A NONCONVEX OPTIMIZATION PROBLEM
R. SRICHANDER Technische Universitaet Berlin, Berlin, Germany Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 18, no. 2 March-April 1995 p. 382-384 refs
(BTN-95-EIX95282706672) Copyright

The efficiency of simulated annealing technique (SA) to solve a particular optimization problem is demonstrated using a practical example from the field of aircraft control. For purposes of comparison, the solution to the optimization problem obtained with the use of NLP technique is also accounted for. It is shown that the nonconvex optimization problem solved using the SA algorithm produces significantly improved results compared to that of constrained NLP algorithm, and the computational overheads are within reasonable limits. EI

A95-89639
APPLICATION OF RESTRUCTURABLE FLIGHT CONTROL SYSTEM TO LARGE TRANSPORT AIRCRAFT
Y. OCHI Natl Defense Acad, Yokosuka, Japan and K. KANAI Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 18, no. 2 March-April 1995 p. 365-370 refs
(BTN-95-EIX95282706666) Copyright

The authors have proposed a flight control system that is able to accommodate failures occurring with the airframe as well as the control effectors. It is based on the feedback linearization method and on-line parameter identification. This paper presents such a system designed for large transport aircraft. The primary contribution is the use of stabilators or engines for feedforward control inputs to counteract disturbances caused by stuck control surfaces. Those effectors are too slow to be used along with other fast control surfaces. However, they can produce large forces or moments, which implies that taking advantage of them would help the aircraft recover from failures. Performance of the control system is demonstrated through computer simulation using a six-degree-of-freedom nonlinear aircraft model of the Boeing 747 aircraft. Author (EI)

A95-90269 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FLIGHT-TESTING AND FREQUENCY-DOMAIN ANALYSIS FOR ROTORCRAFT HANDLING QUALITIES
JOHNNIE A. HAM Edwards AFB, CA, US, CHARLES K. GARDNER Edwards AFB, CA, US, and MARK B. TISCHLER U.S. Army ATCOM, Moffett Field, CA, US American Helicopter Society, Journal (ISSN 0002-8711) vol. 40, no. 2 April 1995 p. 28-38
(HTN-95-01083) Copyright

A demonstration of frequency-domain flight-testing techniques and analysis was performed on a U.S. Army OH-58D helicopter in support of the OH-58D Airworthiness and Flight Characteristics Evaluation and of the Army's development and ongoing review of Aeronautical Design Standard 33C, Handling Qualities Requirements for Military Rotorcraft. Hover and forward flight (60 kn) tests were conducted in 1 flight hour by Army experimental test pilots. Further processing of the hover data generated a complete database of velocity, angular-rate, and acceleration-frequency responses to control inputs. A joint effort was then undertaken by the Airworthiness Qualification Test Directorate and the U.S. Army Aeroflightdynamics Directorate to derive handling-quality information from the frequency-domain database using a variety of approaches. This report documents numerous results that have been obtained from the simple frequency-domain tests; in many areas, these results provide more insight into the aircraft dynmamics that affect handling qualities than do traditional flight tests. The handling-quality results include ADS-33C bandwidth and phase-delay calculations, vibration spectral determinations, transfer-function models to examine single-axis results, and a six-degree-of-freedom fully coupled state-space model. The ability of this model to accurately predict responses was verified using data from pulse inputs. This report also documents the frequency-sweep flight-test technique and data analysis used to support the tests. Author (Herner)

A95-90424
PREDICTIVE ALGORITHMS FOR THE ROLL CONTROL AUTOPILOT OF A JET FIGHTER AIRCRAFT
E. G. KASSAPAKIS University of Reading, Reading, UK and K. WARWICK University of Reading, Reading, UK International Journal of Adaptive Control and Signal Processing (ISSN 0890-6327) vol. 8, no. 4 July-August 1994 p. 359-368
(HTN-95-21047) Copyright

Predictive controllers are often only applicable for open-loop stable systems. In this paper two such controllers are designed to operate on open-loop critically stable systems, each of which is used to find the control inputs for the roll control autopilot of a jet fighter aircraft. It is shown how it is quite possible for good predictive control to be achieved on open-loop critically stable systems.
Author (Herner)

A95-91504
HUBLOAD RESPONSES OF A ROTOR IN FORWARD FLIGHT DUE TO MULTIPLE FREQUENCY BLADE PITCH VARIATIONS
GIZO HASEGAWA National Defense Academy, Japan and TOMOARI NAGASHIMA National Defense Academy, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 116-119 In JAPANESE
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To promote a better understanding of the Higher Harmonic Control, dynamic hub vertical load responses of a rotor in forward flight due to multiple frequency blade pitch variations were investigated while placing emphasis on their aeroelastic behavior. The blade pitch control scheme is described by a linear combination of two sinusoidal terms with arbitrary frequencies which are varied around the integer multiple of the rotor speed. The mathematical model to predict hub vertical load response was formulated based on a linear model, prescribed wake approach. To substantiate the validity of the proposed analytical model as well as the accuracy of numerical results, wind tunnel tests using a model rotor were also conducted. Comparisons of numerical and measured results show reasonable agreement within the scope of this experimental study and the design requirements to realize vibration control system utilizing the Higher Harmonic Control are clarified. Author (Herner)

A95-91505

APPLICATION OF GPS AND FUZZY THEORY TO A HELICOPTER

HIDEHIKO OBAYASHI Kawasaki Heavy Industries Ltd., Japan and EIICHI YAMAKAWA Kawasaki Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 120-123 In JAPANESE

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In order to improve the flight safety of a helicopter, the application of Global Positioning System (GPS) and Fuzzy Theory to a helicopter is studied at Kawasaki Heavy Industries. Some test results are presented in this paper, and these test results shows that GPS and Fuzzy Theory are valuable tools for future autonomous navigation, guidance and control of helicopters. Author (Herner)

A95-91506

DEVELOPMENT OF FLY-BY-WIRE SYSTEM FOR BK117

TAKESHI TOMIO Kawasaki Heavy Industries Ltd., Japan, SYOUJI TANASE Kawasaki Heavy Industries Ltd., Japan, SYUJI NAKAMURA Kawasaki Heavy Industries Ltd., Japan, and MUNENORI ISHIKAWA Kawasaki Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 124-127 In JAPANESE

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Helicopters are widely used in both military and commercial fields. Mission elements have been extended to new areas including IFR (Instrument Flight Rules) operation under all weather conditions, Nap-On-Earth, etc. To accomplish these missions with a lower pilot workload, helicopters have to be equipped with systems that improve flying qualities. A Fly-By-Wire (FBW) system is the most powerful system to meet the requirement. Kawasaki Heavy Industries started the development of the FBW prototype system in 1989 to establish a FBW system suited for helicopters. Flight tests are being conducted, using a BK117. This paper outlines this development. Author (Herner)

A95-91532

A DESIGN OF A ROBUST SCHEDULED AUTOPILOT

TOSHIYUKI TANAKA Japan Defense Agency, Tokyo, Japan, HIROFUMI EGUCHI Japan Defense Agency, Tokyo, Japan, and YASUTAKA AIZAWA Japan Defense Agency, Tokyo, Japan In Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 262-265

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A robust scheduled controller is designed for a multi-input, multi-otput plant which depends on the time-varying variables. The design consists of the following three steps: (1) Figuring the membership functions: A new modeling method for the time-varying system is proposed. The multiple regression analysis or the parameter optimization algorithm leads to the proposed model that is depicted by the multiple models and the membership functions. Each model of the multiple models corresponds to the different selected operating conditions of the plant. The membership functions measure the distance to the operating conditions and interpolate the current plant into the multiple models. (2) Designing the components of a scheduled controller: For each model at each operating condition, the controller can be designed by using some robust control theories. (3) Composing a scheduled controller: The designed components and the membership functions make a scheduled controller so that the membership functions interpolate the current closed loop system into the multiple closed loop models. Since the designed system has not only interpolated gain but also interpolated dynamics, robust property of the closed loop models is expected to be interpolated. The stability condition of the designed system is also presented. For an example, a robust gain scheduled autopilot for F-8 aircraft is designed by applying the H-infinity control theory. Author (Herner)

A95-91533

A DESIGN OF A SELF-LEARNING ROBUST SCHEDULED AUTOPILOT

TOSHIYUKI TANAKA Japan Defense Agency, Tokyo, Japan, YASUTAKA AIZAWA Japan Defense Agency, Tokyo, Japan, and HIROFUMI EGUCHI Japan Defense Agency, Tokyo, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 266-269

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A robust scheduled controller is designed for a multi-input, multi-output plant which depends on the slowly varying variables. The scheduling function is automatically learned by the neural networks. The design consists of the following three steps: (1) Training the membership function emulator: A time-varying system is depicted by the multiple models and membership function. Each model of the multiple models corresponds to different selected operating conditions of the plant. The membership function is a scheduling function. Although the concept of the membership function is similar to the one used in fuzzy control theory, the membership function can be given not by the designer's experience but by parameter optimization or multiple regression analysis. However, not only these analyses are too complicated but also the membership function may be strongly nonlinear. In this paper, the multilayered neural networks are used to emulate the membership function through a self-learning process. (2) Designing the components of a schedules controller: For each model, the controller can be designed by using the H-infinity robust control theory, and produces the multiple closed loop models. (3) Composing a scheduled controller: The designed components and the membership function emulator make a scheduled controller so that the membership function emulator interpolate the current closed loop system into the multiple closed loop models. Since the designed scheduler has not only interpolated gain but also interpolated dynamics, robust property of the closed loop model is expected to be interpolated. For an example, a robust gain scheduled autopilot for F-8 aircraft is designed. Author (Herner)

A95-91534

DESIGN OF A FLIGHT CONTROL SYSTEM BY A NEW WAY OF POLE PLACEMENT IN LQR

YOSHIMASA OCHI National Defense Academy, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 270-273

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This paper presents a way of pole placement in the linear quadratic regulator (LQR) and its application to the design of a flight control system. There are three features in the proposed method. First a weighting matrix which gives desired closed-loop pole locations is obtained by solving differential equations. Secondly the method can place poles arbitrarily and exactly at desired positions. Thirdly a weighting matrix obtained is a diagonal one. It is applied to stabilization of lateral-directional motions of Boeing 747. Simulation results are compared to those obtained by conventional pole placement. Author (Herner)

A95-91551
AN APPLICATION OF TLS (TOTAL LEAST SQUARES) METHOD TO ESTIMATION OF AIRCRAFT AERODYNAMIC DERIVATIVES
KAZUYA MASUI National Aerospace Lab., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 410-413 In JAPANESE
Copyright

The Total Least Squares (TLS) method estimates unknown linear equation coefficients assuming that both the explanatory variables and the objective variable are affected by measurement errors. The TLS method gives correct coefficients and standard deviations of them. An example of estimating aerodynamic derivatives from flight test data is also presented. Author (Hemer)

A95-91554
A SYSTEMS FOR FLIGHT DATA ACQUISITION AND ANALYSIS FOR A REMOTELY-PILOTED RESEARCH VEHICLE
AKIRA SAKURAI Kyushu Univ., Japan, SHIN'ICHIRO HIGASHINO Kyushu Univ., Japan, NATSUKO KUDO Kyushu Univ., Japan, and MANABU MATSUBARA Kyushu Univ., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 422-425 In JAPANESE
Copyright

A system for flight data acquisition and analysis for a remotely-piloted research vehicle (RPRV) has been developed. Various kinds of flight data such as the airspeed, the angle of attack, the side slip angle, the angular rates, the accelerations, and the control surface deflections are processed by an on-board computer and recorded by a very small digital audio tape (DAT) recorder. The acquired data are analyzed on a personal computer for estimation of aerodynamic characteristics of the RPRV. This paper shows an outline of the data acquisition and analysis system. Author (Hemer)

A95-91561
AEROSERVOELASTIC COUPLING ON THE UF-104 AIRCRAFT
JUNICHIRO SUMITA Mitsubishi Heavy Industries Ltd., Nagoya, Japan, NOBUO TODA Mitsubishi Heavy Industries Ltd., Nagoya, Japan, KIYOSHI SAKURA Mitsubishi Heavy Industries Ltd., Nagoya, Japan, and HIROYUKI TANAKA Mitsubishi Heavy Industries Ltd., Nagoya, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 454-457 In JAPANESE
Copyright

Aeroservoelastic (ASE) coupling analysis was conducted during the UF-104 development. ASE characteristics of the mother aircraft (F-104J) were modified by the installation of a new three axis rate gyro, a new Nz sensor, and the Drone Flight Control Complex (DFCC). The ASE coupling analysis with the model based on the Ground Vibration Test (GVT) revealed that the aircraft was stable. This was confirmed by flight tests. Author (Hemer)

A95-91680
ASTOVL AIRCRAFT: SOME THOUGHTS ON NEW CONTROL STATEGIES
R. W. PRATT 1991 6 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 5: Flight Simulation 1)
(CONGRESS PAPER C428-5-011; HTN-95-21111) Copyright

Active Control Technology (ACT) is essential for an aircraft which is open-loop unstable. Also, it provides an opportunity to give the pilot direct control of the parameters which are relevant to the aircraft's flight path, for example, ground speed and flight-path angle rather than the conventional use of thrust and pitch rate. For the purposes of this project Adanced Short Take-off and Vertical Landing (ASTOVL) is considered to refer to an aircrafrt with vectored thrust with an advanced flight control system (FCS) based on active control technology (ACT) which is very likely to be intergrated with the power control system (PCS). The paper discusses the need to exercise care in balancing the relative levels of control authority vested in the flight control system and the pilot. It is argued that the operational capability of the aircraft will be developed more rapidly and effectively if the pilot has the greater influence. Author (Hemer)

A95-91700
UNIVERSAL ELECTROHYDRAULIC SYSTEM FOR THE STEERING GEAR LOADING.
L. M. KORYAKIN, B. S. MANUKYAN, and D. A. PARKHOMOV 1991 5 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 10: Flight Simulation 2)
(CONGRESS PAPER C428-10-106; HTN-95-21131) Copyright

Two types of the problem appear in the practise of loaded control actuator testing. One of them is the determination of natural loading characteristics of the actuator, i.e., mechanical properties and dynamic stiffness (or mechanical impedance). These problems can be solved by rather simple technical tools. For complicated cases the electrohydraulic or electromechanical loading fixture with a positioned feedback is used for reproducing subsidence of the output component of the tested actuator as an elastic dynamic system, and the force response is measured. The other type of experimental problem is related to the tests of actuator/load dynamic system. An actuator with the load applied may be considered as a closed single-circuit dynamic loop of the two tandem components. One of these components is determined only by the parameters of the tested actuator; the force P is its input on the output component, and its output is the displacement of the rod Y. The other component is described by the loading characteristics with the input signal being Y, and the output-force applied to the rod/aircraft control attachment point. Author (revised by Hemer)

A95-91721
THEORY AND EVALUATION OF ACTIVE CONTROL AS A MEANS OF REDUCING HELICOPTER VIBRATION
A. E. STAPLE 1991 8 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 19: Rotorcraft)
(CONGRESS PAPER C428-19-124; HTN-95-21152) Copyright

The theory, development and flight evaluation at Westland Helicopters of an active control system, for minimizing helicopter vibration, termed Active Control of Structural Response (ACSR) is described. Results from the recent flight development program on the Westland-Agusta EH103 heliocopter are presented which illustrate the major performance benefits of such a technique for the next generation of rotorcraft. Author (Hemer)

A95-91722
PASSIVE AND ACTIVE VIBRATION CONTROL ACTIVITIES IN THE GERMAN HELIOCOPTER INDUSTRY
H. STREHLOW 1991 17 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 19: Rotorcraft)
(CONGRESS PAPER C428-19-126; HTN-95-21153) Copyright

A survey of past and current activities at MBB for heliocopter vibration control is presented. Both passive and active means for the reduction of rotor-induced airframe vibrations are reviewed. Emphasis is placed on passive and active rotor isolation systems as well as modern active blade vibration rejection control concepts using fixed system higher harmonic swash plate control or individual blade control in the rotating system. Results of theoretical and experimental investigations are presented including recent flight test measurments. Author (Hemer)

N95-29156 Kansas Univ. Center for Research, Inc., Lawrence, KS.
APPLICATION OF OPTIMIZATION TECHNIQUE TO CONTROL SYSTEM DESIGN FOR DEPARTURE PREVENTION AND AIRCRAFT MODEL ESTIMATION THROUGH DYNAMIC INVERSION Ph.D. Thesis

FUYING GE 1993 222 p
Avail: Univ. Microfilms Order No. DA9425908

The numerical optimization technique allows one to formulate a nonlinear problem in an easily understandable manner. The objective of increasing the performance and maneuverability without departure/spin is established in a simple mathematical expression and by sets of constraints. The feedback gains in the control system and unknown coefficients present in aircraft models are defined as design variables. The maneuver boundaries for departure prevention are directly characterized by motion parameters, alpha, beta, p, q, and r, and inequality constraints. The optimizer automatically cycles through the combinations of design variables to determine the best design satisfying the objective without violating the maneuver boundaries. Both the processes of defining the system or models (the design process) and the process of determining the response of the specified system or models (the analysis process) are directly based on the six degree-of-freedom (6-DOF) dynamic simulation. Therefore the complex nature of the aerodynamics, and dynamics and interactions at high angles of attack addressed in the 6-DOF equations of motion are included in the control system design and/or aircraft model estimation. The design of an aileron-rudder-interconnect (ARI) and stability yaw damper using this method is demonstrated for a F-5A configuration. The design of an angle-of-attack limiter is demonstrated using an F-16 configuration to prevent coupled pitch and yaw departure. The mathematical model to be estimated is related to the nonlinear characteristics at high angles of attack flight conditions. Using the present optimization technique, a control system to provide good maneuverability and high departure/spin resistance can be designed simultaneously with aircraft model estimation.

Dissert. Abstr.

N95-29680 Stanford Univ., CA.

LINEAR MATRIX INEQUALITIES FOR THE PROBLEM OF ABSOLUTE STABILITY OF CONTROL SYSTEMS Ph.D. Thesis

ERIC MARIE FERON 1994 102 p
Avail: Univ. Microfilms Order No. DA9414567

The problem of absolute stability of dynamic systems deals with the stability of linear systems perturbed by different classes of unknown elements. These elements are unsteady, nonlinear or simply unknown, constant gains. These systems, which encompass a broader class than linear time invariant systems, are able to better represent physical systems. Many techniques have been developed in the past to study them the famous Circle and Popov criteria, for example. They are graphical procedures and their practical use is limited to one element. In this thesis, we propose to show how advances in computer power and convex optimization allow us to extend these criteria to multiple elements. We also present an extension of these criteria that can be used to derive performance bounds.

Dissert. Abstr.

N95-30254*# Kansas Univ. Center for Research, Inc., Lawrence, KS.

DESIGN, ANALYSIS AND CONTROL OF LARGE TRANSPORTS SO THAT CONTROL OF ENGINE THRUST CAN BE USED AS A BACK-UP OF THE PRIMARY FLIGHT CONTROLS Ph.D. Thesis

JAN ROSKAM, DEANE E. ACKERS, and DONNA S. GERREN Apr. 1995 463 p
(Contract(s)/Grant(s): NAG2-789)
(NASA-CR-198958; NAS 1.26:198958) Avail: CASI HC A20/MF A04

A propulsion controlled aircraft (PCA) system has been developed at NASA Dryden Flight Research Center at Edwards Air Force Base, California, to provide safe, emergency landing capability should the primary flight control system of the aircraft fail. As a result of the successful PCA work being done at NASA Dryden, this project investigated the possibility of incorporating the PCA system as a backup flight control system in the design of a large, ultra-high capacity megatransport in such a way that flight path control using only the engines is not only possible, but meets MIL-Spec Level 1 or Level 2 handling quality requirements. An 800 passenger megatransport aircraft was designed and programmed into the NASA Dryden simulator. Many different analysis methods were used to evaluate the flying qualities of the megatransport while using engine thrust for flight path control, including: (1) Bode and root locus plot analysis to evaluate the frequency and damping ratio response of the megatransport; (2) analysis of actual simulator strip chart recordings to evaluate the time history response of the megatransport; and (3) analysis of Cooper-Harper pilot ratings by two NaSA test pilots.

Author

N95-30327*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

MANUAL FOR A WORKSTATION-BASED GENERIC FLIGHT SIMULATION PROGRAM (LARCSIM), VERSION 1.4

E. BRUCE JACKSON May 1995 142 p
(Contract(s)/Grant(s): RTOP 505-64-52-01)
(NASA-TM-110164; NAS 1.15:110164) Avail: CASI HC A07/MF A02

LaRCsim is a set of ANSI C routines that implement a full set of equations of motion for a rigid-body aircraft in atmospheric and low-earth orbital flight, suitable for pilot-in-the-loop simulations on a workstation-class computer. All six rigid-body degrees of freedom are modeled. The modules provided include calculations of the typical aircraft rigid-body simulation variables, earth geodesy, gravity and atmospheric models, and support several data recording options. Features/limitations of the current version include English units of measure, a 1962 atmosphere model in cubic spline function lookup form, ranging from sea level to 75,000 feet, rotating oblate spheroidal earth model, with aircraft C.G. coordinates in both geocentric and geodetic axes. Angular integrations are done using quatemion state variables Vehicle X-Z symmetry is assumed.

Author

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RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A95-87249

FLIGHT SIMULATORS: BETTER THAN THE REAL THING?

TREVOR NASH Air International (ISSN 0306-5634) vol. 46, no. 3 March 1994 p. 152-158
(HTN-95-42619) Copyright

With the costs of flight time steadily escalating, simulators are an increasingly important element of flight training. The history of simulators is charted and their current role in military and civil aviation is described.

Author (Hemer)

A95-87391

THE HIGH ENTHALPY SHOCK TUNNEL IN GOETTINGEN (HEG)

W. H. BECK Institute for Experimental Fluid Mechanics, Goettingen, Germany, G. EITELBERG Institute for Experimental Fluid Mechanics, Goettingen, Germany, and T. J. MCINTYRE Institute for Experimental Fluid Mechanics, Goettingen, Germany In Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 257-268
Copyright

The current status of the new free piston shock tunnel (HEG) being built in Gottingen is described. The facility is nearing completion with all major components on site and assembled. HEG represents a considerable scale up on existing facilities of this type and consideration of the energies involved must be taken in all aspects

of the design. Described are the layout of the facility, calculation of the driving conditions including piston trajectories, expectations for the shock tube flow and calculation for the nozzle flow.
Author (Herner)

A95-87411
MEASUREMENT OF FREE-FLIGHT DYNAMIC STABILITY DERIVATIVES OF CONES IN A HYPERSONIC GUN TUNNEL
H. O. LEWIS University of Southampton, UK and R. A. EAST University of Southampton, UK 1995 9 p. AIAA, International Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, April 3-7, 1995 Research sponsored by the Defence Research Agency
(AIAA PAPER 95-6082; HTN-95-92595) Copyright
This paper discusses a novel method for the measurement of dynamic stability derivatives of cones in a hypersonic gun tunnel using the free-flight technique. The development of the method is outlined and preliminary results for two 10 deg semi-angle pointed cones are presented. The results using the present method are compared with results obtained from previous experiments and theoretical calculations. Author (Herner)

A95-88010* National Aeronautics and Space Administration, Washington, DC.
THE NASA-SPONSORED MARYLAND CENTER FOR HYPERSONIC EDUCATION AND RESEARCH
MARK J. LEWIS University of Maryland, College Park, MD, US and ASHWANI K. GUPTA University of Maryland, College Park, MD, US 1995 10 p. AIAA International Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, April 3-7, 1995
(Contract(s)/Grant(s): NAGW-3715)
(AIAA PAPER 95-6105; HTN-95-92649) Copyright
The Office of Aeronautics of the National Aeronautics and Space Administration has established a program to support university programs in the field of hypersonic flight. Beginning in the fall of 1993, three universities, including the University of Maryland at College Park, were selected to participate in this activity. The program at the University of Maryland includes faculty in the Department of Aerospace Engineering and Department of Mechanical Engineering, and provides a multidisciplinary environment for graduate and undergraduate students to study and conduct research in the field of hypersonic flight. Ongoing projects cover the range of applications from cruisers through transatmospheric and reentry vehicles. Research activities, focused on propulsion, fluid dynamics, inverse design, and vehicle optimization and integration, are conducted in conjuntion with industrial partners and government laboratories. Author (Herner)

A95-88901
OPERATION OF THE ADAPTIVE-WALL WIND TUNNEL OF TSAGI, MOSCOW
V. M. NEYLAND TSAGI, Moscow, Russia, A. V. SEMENOV, and O. K. SEMENOVA *In* Symposium on Aerodynamics & Aeroacoustics, Tucson, AZ, March 1-2, 1993. A95-88892 Singapore World Scientific Pub. Co. Pte. Ltd. (Advanced Series on Fluid Mechanics) 1994 p. 259-280
Copyright
The history of the development of the adaptive-wall wind tunnel is well known, primarily due to the studies of Wolf and Goodyer (1987). They discovered publications describing the experiments carried out in such a facility as early as in the pre-war years. However, the second and true birth of the concept of the adaptive boundaries on the flow is closely related to the names of Sears (1974) and Ferri and Baronti (1974). Sears is considered a father of adaptive walls and has based his idea on a well-known principle of solid stream lines. For many years Russia was carrying out its studies on its own, repeating, or sometimes anticipating, the achievements of Western states. However, the idea of wall boundary conditions controlled by segmented gas blowing-suction, though proposed, has been throughly investigated by computations and theoretically but was never applied in practise. Instead, at the end of the 1960's TsAGI began to develop a project of a large industrial wind tunnel, T-128, with perforated adaptive panels on the test section walls. The project had been completed by 1976, and the facility itself was put into service in 1982. The new configuration of test section walls was aimed at minimization of harmful effect of flow boundaries on the flow past a model optimum adjustment of local perforation. This adjustment should be performed automatically by the controlling computer. During years of its operation certain advantages (rather significant) as well as drawbacks (which can be eliminated) were found out. The present paper discusses some experimental results obtained in T-128 and gives a brief description of the facility itself. Author (revised by Herner)

A95-88902* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ADAPTIVE-WALL WIND-TUNNEL RESEARCH AT AMES RESEARCH CENTER: A RETROSPECTIVE
EDWARD T. SCHAIRER NASA Ames, Moffett Field, CA, US *In* Symposium on Aerodynamics & Aeroacoustics, Tucson, AZ, March 1-2, 1993. A95-88892 Singapore World Scientific Pub. Co. Pte. Ltd. (Advanced Series on Fluid Mechanics) 1994 p. 281-321
Copyright
This paper reviews adaptive-wall wind-tunnel research conducted at Ames Research Center between 1978 and 1988. This research focused on developing ways to apply the concept of adaptive walls in transonic test sections with ventilated walls. In the approach pursued at Ames, local mass flow through slotted test-section walls was controlled by adjusting the pressure in compartments of a segmented plenum; the flow measurements required to test compatibility of the wind-tunnel flow with free-air boundary conditions were made using a laser velocimeter; empirical influence coefficients were used to predict how pressure changes in the plenum would effect the flow. Both two- and three-dimensional proof-of-concept experiments were conducted in a small indraft wind tunnel. Subsequently, a two-dimensional test section was demonstrated in the Ames 2x2 ft. Transonic Wind Tunnel-a wind tunnel representative of a production facility. The 2x2 ft. tests showed large reductions of wall interference; however, the time required to make the necessary flow measurements and plenum pressure adjustments far exceeded what would be acceptable for production testing. This was primarily because the imaginary surface where free-air compatibility was tested had to be separated from the test section walls to avoid the complex, viscous flow adjacent to the walls. It is unlikely that the Ames approach to adaptive walls will be applied in production wind tunnels. The two biggest unresolved problems are how to quickly and accurately make the necessary flow measurements and how to predict the effects of wall adjustments. In contrast, flexible-wall technology for two-dimensional testing is ready for application in production wind tunnels. However, neither the ventilated- nor flexible-wall approach has been shown to be a technically viable and cost-effective solution to the three-dimensional adaptive wall problem. Author (Herner)

A95-88903* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ADAPTIVE WALL TECHNOLOGY FOR MINIMIZATION OF WIND TUNNEL BOUNDARY INTERFERENCES - WHERE ARE WE NOW?
STEPHEN W. D. WOLF NASA Ames, Moffett Field, CA, US In Symposium on Aerodynamics & Aeroacoustics, Tucson, AZ, March 1-2, 1993. A95-88892 Singapore World Scientific Pub. Co. Pte. Ltd. (Advanced Series on Fluid Mechanics) 1994 p. 323-370
Copyright
The status of adaptive wall technology to improve wind tunnel simulations for 2- and 3-D testing is reviewed. This technology relies on the test section flow boundaries being adjustable, using a tunnel/computer system to control the boundary shapes without knowledge of the model under test. This paper briefly overviews the benefits and shortcomings of adaptive wall testing techniques. A historical perspective highlights the disjointed development of these testing techniques from 1938 to present. Currently operational transonic

Adaptive Wall Test Sections (AWTSs) are detailed, showing a preference for the simplest AWTS design with two solid flexible walls. Research highlights show that quick wall adjustment procedures are available and AWTSs, with impervious or ventilated walls, can be used through the transonic range up to M(sub infinity) = 1.2. The requirements for production testing in AWTSs are discussed, and conclusions drawn as to the current status of adaptive wall technology. In 2-D testing, adaptive wall technology is mature enough for general use, even in cryogenic wind tunnels. In 3-D testing, this technology has not been pursued aggressively, because of the inertia against change in testing techniques, and preconceptions about the difficulties of using AWTSs. Author (Herner)

A95-90438
THE NASA/UTA CENTER FOR HYPERSONIC RESEARCH
D. WILSON University of Texas at Arlington, Arlington, Texas, US, D. ANDERSON University of Texas at Arlington, Arlington, Texas, US, and W. CHAN University of Texas at Arlington, Arlington, Texas, US 1995 11 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(AIAA PAPER 95-6106; HTN-95-B0357) Copyright

The NASA/UTA Center for Hypersonic Research is one of three NASA-sponsored centers for graduate-level education and research in hypersonic aeronautics. The primary objectives of the Center are to develop modern educational programs in hypersonics, and to provide graduate students with opportunities to conduct state-of-the-art research in the technical disciplines that are critical to the development of hypersonic flight vehicles. The NASA/UTA Center is co-sponsored by the Lockheed Fort Worth Company - a major aerospace company in the Dallas-Fort Worth area with active programs in hypersonics. A comprehensive educational program leading to M.S. and Ph.D. degrees in Aerospace, Mechanical, or Materials Science and Engineering, with specialization in hypersonics is being developed. The educational program builds on a solid base of fundamental courses in the mathematical and engineering sciences, and provides specialized courses in hypersonic aerodynamics, aerothermodynamics, propulsion, high-temperature materials, structures, flight dynamics, and hypersonic vehicle design. Complementary research programs focus on the high-temperature aspects of sustained flight at hypersonic speeds, with particular emphasis in the areas of aerodynamics, aerothermodynamics, propulsion, structures and materials. A detailed description of the education and research programs in hypersonics at UTA, as well as a description of the supporting research facilities, is presented in the paper. Author (Herner)

A95-90439* National Aeronautics and Space Administration, Washington, DC.
RESEARCH AND EDUCATIONAL INITIATIVES AT THE SYRACUSE UNIVERSITY CENTER FOR HYPERSONICS
E. SPINA Syracuse University, Syracuse, New York, US, J. LAGRAFF Syracuse University, Syracuse, New York, US, B. DAVIDSON Syracuse University, Syracuse, New York, US, E. BOGUCZ Syracuse University, Syracuse, New York, US, and T. DANG Syracuse University, Syracuse, New York, US 1995 9 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(Contract(s)/Grant(s): NAGW-3713; NAG1-1400; NGT-51171; NGT-70380; NSF EEC-93-00414)
(AIAA PAPER 95-6107; HTN-95-B0358) Copyright

The Department of Mechanical, Aerospace, and Manufacturing Engineering and the Northeast Parallel Architectures Center of Syracuse University have been funded by NASA to establish a program to educate young engineers in the hypersonic disciplines. This goal is being achieved through a comprehensive five-year program that includes elements of undergraduate instruction, advanced graduate coursework, undergraduate research, and leading-edge hypersonics research. The research foci of the Syracuse Center for Hypersonics are three-fold; high-temperature composite materials, measurements in turbulent hypersonic flows, and the application of high-performance computing to hypersonic fluid dynamics. Author (Herner)

A95-90443
THE USE OF THERMOCHROMIC LIQUID CRYSTALS FOR HEAT TRANSFER MEASUREMENTS IN SHORT DURATION HYPERSONIC WIND TUNNEL FACILITIES
G. ROBERTS University of Southampton, Southampton, UK and R. EAST University of Southampton, Southampton, UK 1995 9 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(AIAA PAPER 95-6115; HTN-95-B0362) Copyright

In this paper, the use of thermochromic liquid crystals for quantitative heat flux measurements in hypersonic wind tunnel facilities with run-times O(1)s is reviewed. It is shown that the advantages conferred by this technique, in terms of ease and economy of model instrumentation, must be weighed against the difficulties encountered in calibration and image interpretation. Nevertheless, the ability to provide a high spatial resolution thermal map of the entire model makes this technique very attractive for determining the heat flux to models which are experiencing complex flows. Author (Herner)

A95-90449
REVIEW OF NEW FRENCH FACILITIES FOR PREPHA PROGRAM
A. CHEVALIER Aerospatiale Missiles, Bourges, France and F. FALEMPIN ONERA, Palaiseau, France 1995 5 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(AIAA PAPER 95-6128; HTN-95-B0368) Copyright

In the scope of PREPHA program, AERSPATIALE, ONERA, SEP, SNECMA and DASSAULT work together on research about supersonic combustion and hydrogen-fueled scramjet technology. This program has made necessary the building of very powerful and efficient new test facilities, and the modification of some already built facilities at AEROSPATIALE MISSILES and at ONERA. These are operational now, and allow us to carry out supersonic combustion tests up to Mach 7.5 flight conditions. Several even better new test facilities are studied, and could rapidly be built. Author (Herner)

A95-90454
A REVIEW OF FREE-STREAM FLOW FLUCTUATION AND STEADY-STATE FLOW QUALITY MEASUREMENTS IN THE AEDC/VKF SUPERSONIC TUNNEL A AND HYPERSONIC TUNNEL B
J. DONALDSON Micro Craft Technology Inc, Arnold AFB, Tennessee, US and S. COULTER Micro Craft Technology Inc, Arnold AFB, Tennessee, US 1995 17 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(AIAA PAPER 95-6137; HTN-95-B0373) Copyright

Monitoring and documenting the flow quality of the test facilities at Arnold Engineering Development Center (AEDC) is a continuous process. Both dynamic and steady-state measurements are made periodically as a 'health' check on the test facility flow quality. Over a period of years, measurements of fluctuations in the free-stream flow in the test sections of AEDC Supersonic and Hypersonic Tunnels A and B have been made, using constant-current hot-wire anemometer techniques. The results for Mach numbers 4 and 5 in Tunnel A and 6 and 8 in Tunnel B cover the available range of unit Reynolds number. These measurements have been reviewed and are compiled for the first time and reported in this paper. In the case of Tunnel B, the data cover the period from 1972 through 1992 and show no evidence that the flow fluctuations have changed over that time period. The history of turbulence measurements and AEDC's instrumentation methodology are reviewed. The steady-state flow quality calibrations were obtained for the Mach 6 and Mach 8 nozzles of Tunnel B, and the Mach 10 Tunnel C nozzle. The Mach 8 calibration is reviewed in this paper. Author (Herner)

A95-90461 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

OPERATING CAPABILITY AND CURRENT STATUS OF THE REACTIVATED NASA LEWIS RESEARCH CENTER HYPERSONIC TUNNEL FACILITY

S. THOMAS NASA Lewis Research Center, Cleveland, Ohio, US, C. TREFNY NASA Lewis Research Center, Cleveland, Ohio, US, and W. PACK NASA Lewis Research Center, Cleveland, Ohio, US 1995 11 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(AIAA PAPER 95-6146; HTN-95-B0380) Copyright

The NASA Lewis Research Center's Hypersonic Tunnel Facility (HTF) is a free-jet, blowdown propulsion test facility that can simulate up to Mach-7 flight conditions with true air composition. Mach-5, -6, and -7 nozzles, each with a 42-in. exit diameter, are available. Previously obtained calibration data indicate that the test flow uniformity of the HTF is good. The facility, without modifications, can accomodate models approximately 10 ft long. The test gas is heated using a graphite core induction heater that generates a nonvitiated flow. The combination of clean-air, large-scale, and Mach-7 capabilities is unique to the HTF and enables an accurate propulsion performance determination. The reactivation of the HTF, in progress since 1990, includes refurbishing the graphite heater, the steam generation plant, the gaseous oxygen system, and all control systems. All systems were checked out and recertified, and environmental systems were upgraded to meet current standards. The data systems were also upgraded to current standards and a communication link with NASA-wide computers was added. In May 1994, the reactivation was complete, and an integrated systems test was conducted to verify facility operability. This paper describes the reactivation activities, the facility status, the operating capabilities,and specific applications of the HTF. Author (revised by Hemer)

A95-90464 National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

A FLYING QUALITIES STUDY OF LONGITUDINAL LONG-TERM DYNAMICS OF HYPERSONIC PLANES

T. COX NASA Dryden Flight Research Center, Edwards, California, US, G. SACHS Technical University of Munich, Munich, Germany, A. KNOLL Technical University of Munich, Munich, Germany, and R. STICH Technical University of Munich, Munich, Germany 1995 23 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(AIAA PAPER 95-6150; HTN-95-B0383) Copyright

The NASA Dryden Flight Research Center and the Technical University of Munich are cooperating in a research program to assess the impact of unstable long-term dynamics on the flying qualities of planes in hypersonic flight. These flying qualities issues are being investigated with a dedicated flight simulator for hypersonic vehicles located at NASA Dryden. Several NASA research pilots have flown the simulator through well-defined steady-level turns with varying phugoid and height mode instabilities. Th data collected include pilot ratings and comments, performance measurements, and pilot workload measurements. The results presented in this paper include design guidelines for height and phugoid mode instabilities, an evaluation of the tapping method used to measure pilot workload, a discussion of techniques developed by the pilots to control large instabilities, and a discussion of how flying qualities of unstable long-term dynamics influence control power design requirements. Author (revised by Hemer)

A95-90465

THE PANEL OXIDATION AND EROSION TEST (POET) FACILITY

W. SWARTWOUT General Applied Science Laboratories Inc., Ronkonkoma, New York, US, R. ENGERS General Applied Science Laboratories Inc., Ronkonkoma, New York, US, and D. RUBIN General Applied Science Laboratories Inc., Ronkonkoma, New York, US 1995 11 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(AIAA PAPER 95-6151; HTN-95-B0384) Copyright

A critical requirement in the design and evaluation of materials and structures capable of withstanding the harsh environment experienced in hypersonic flight is to have a ground test facility that can reproduce those conditions. This must include the ability to not only generate representative heat flux levels, but to do so while maintaining an oxidizing and eroding environment. The Panel Oxidization and Erosion Testbed (POET) Facility was built to satisfy these requirements. This facility permits each test parameter, including oxygen content to be fully variable. This provides for an effective evaluation of flight panels intended for all locations on an aircraft, including engine inlet, combustor and nozzle. With two years of operation completed, POET is a mature facility having performed nearly 200 tests, demonstrating test durations of up to 15 minutes. The significant growth of the propellant and coolant supply infrastructure along with the proven test technique enables General Applied Science Laboratories (GASL) to now expand testing to include full size articles. Author (revised by Hemer)

A95-90649

INTELLIGENT TUTORING SYSTEM: F-16 FLIGHT SIMULATION

BETTINA A. BABBITT Northrop Grumman Corporation, Pico Rivera, CA, US, HERBERT H. BELL USAF, Mesa, AZ, US, H. BARBARA SORENSEN USAF, Brooks AFB, TX, US, and SALLIE E. GORDON University of Idaho, Moscow, ID, US *In* AIAA Computing in Aerospace 10, San Antonio, TX, March 28-30, 1995. A95-90629 Washington, DC American Institute of Aeronautics and Astronautics 1995 p. 173-179
Copyright

Northrop Grumman Corporation, Armstrong Laboratory, and the University of Idaho have applied cognitive conceptual representation for decision making to produce a proof-of concept Intelligent Tutoring System (ITS) F-16 flight simulation. Intelligent tutoring systems have application wherever critical decision making is required. The project objective is to evaluate the use and utility of knowledge engineering methods that will have future application to military and commercial training in decision making. This phase of the project focused on developing an intelligent tutoring system that could be used with aircrew training devices for training air intercept tracking and sorting. Non-military applications for the dual use technology include complex command and control situations such as air traffic control, ground transportation command and control, nuclear and electrical power control rooms. The biomedical field is also a candidate for the technology described in this article. Author (Hemer)

A95-91535

AN INTELLIGENT TUTORING SYSTEM FOR CIVIL AVIATION FLIGHT TRAINING

FAISAL ZEIDAN Kyoto Univ., Kyoto, Japan and MAKOTO KOBAYAKAWA Kyoto Univ., Kyoto, Japan Japan Japan Aerospace Association 1992 p. 274-279 In: Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992 Research sponsored by Japanese Monbusho and Venezuelan Council for Science and Technology
Copyright

This paper is a general approach to an Intelligent Tutoring System for Civil Aviation (ITSCA) flight training that incorporates artificial intelligence techniques to enhance training and learning capabilities. The limited scope of traditional educational approaches such as the classroom, and the need to generate unique training scenarios for each pilot based on a individualized training strategy are the most important problems in teaching cognitive knowledge and physical skills. The apprenticeship approach to training based on one-to-one attention, and emphasizing specific applications and tasks, could help to solve this training problem. Also, an ITSCA can allow performing of pre-flight and post-flight debriefs. During the debriefs, the ITSCA reminds the pilot of problem areas identified in earlier flights, recaps the training session highlighting both the positive and negative aspects, and automatically provides tutoring about specific areas to be worked on in the future where corrective actions are necessary. Author (Hemer)

A95-91553
DETERMINATION OF FLIGHT SIMULATOR TIME DELAY
MITSUMASA SATO Kawasaki Heavy Industries Ltd., Japan, TATSURO HINGU Kawasaki Heavy Industries Ltd., Japan, and YUKIHIRO TATUTA Kawasaki Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 418-421 In JAPANESE
Copyright

This paper describes the simulator architecture, techniques and results of measuring time delays, and discussion. Measurements showed that the average delays for several systems were approximately 75 to 93 msec. These are sufficiently less than the time delays reported in the literature for other simulators. Author (Hemer)

A95-91555
FUNCTIONS OF NAL FIXED BASE SIMULATOR FOR HELICOPTER RESEARCH
AKIRA WATANABE National Aerospace Lab., Japan, KAORU WAKAIRO National Aerospace Lab., Japan, HIROYASU KAWAHARA National Aerospace Lab., Japan, KEIJI TANAKA National Aerospace Lab., Japan, and KOHEI FUNABIKI National Aerospace Lab., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 426-429
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The National Aerospace Laboratory (NAL) started the study on the Helicopter Flight Safety in 1990. In this study a new simple flight simulator was constructed aiming at investigating effects of visual information upon the helicopter pilot's visual information. The simulator is fixed base cockpit type and utilizes the large screens. Before beginning the simulation study, we evaluated the functions of the simulator. The lower sight of the simulator was a little insufficient and the control system had improper nonlinearities. After improvements, the simulator was effectively utilized for the simulation study of the visual information. Author (Hemer)

A95-91556
A SIMULATOR STUDY ABOUT EFFECTS OF VISIBILITY UPON HELICOPTER PILOT PERFORMANCE
KOHEI FUNABIKI National Aerospace Lab., Japan, KEIJI TANAKA National Aerospace Lab., Japan, HIROYASU KAWAHARA National Aerospace Lab., Japan, KAORU WAKAIRO National Aerospace Lab., Japan, and AKIRA WATANABE National Aerospace Lab., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 430-433
Copyright

A flight simulation was conducted to investigate the relationship between visibility and helicopter pilot performance. For this purpose, a fixed-base helicopter simulator with a two-channel computer generated visual system was prepared, where the stability derivatives of the BO-105 model were utilized. Pilot tasks were to perform a hover and to follow a traffic pattern around a simulated airport, under three level visibility conditions; Clear, 3000 m range, and 500 m range. In addition to flight data and pilot comments, eye point tracking data were obtained. Results of the power spectral analysis about control stick movements showed that the visibility affected most significantly to the lateral cyclic control during level flight. The eye point tracking data revealed that the pilot derived visual cues for attitude control from the attitude indicator in the case of low visibility. It also became apparent from the pilot comments and other results that the simulator could not provide sufficient information for low altitude maneuvers. Author (Hemer)

A95-91577
DEVELOPMENT OF A PILOT TUBE WITH MULTI-HOLE PYRAMIDAL HEAD. 2: A FIVE-HOLE YEW PROBE OF ENGINEERING MODEL
T. NAKAYA National Aerospace Lab., Japan, S. SUZUKI National Aerospace Lab., Japan, N. KUWANO National Aerospace Lab., Japan, A. HANZAWA National Aerospace Lab., Japan, T. SAITO Tokyo Aircraft Instrument Co. Ltd., Japan, M. USAMI Tokyo Aircraft Instrument Co. Ltd., Japan, and T. IWATA Tokyo Aircraft Instrument Co. Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 562-563 In JAPANESE
Copyright

This paper deals with the practical thick pyramidal probe design and wind tunnel test. A pressure guide tube with multi-holes on each face of the practical probe allows the similarity of pressure profile with the trial thin probe. The probe measures airspeed. Author (Hemer)

A95-91678
NEW COMPUTER DELIVERED TRAINING SYSTEMS TO SUPPORT TECHNICAL CREW TRAINING PROGRAMMES
C. S. SMITH 1991 3 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 5: Flight Simulation 1)
(CONGRESS PAPER C428-5-036; HTN-95-21109) Copyright

New media for technology based training are discussed including digital video, digital audio, animation and multi screen presentation. The significance of hardware and software advances is explained. New two dimensional simulations for aircraft systems training are described. Author (Hemer)

A95-91679
THE ADVANCED FLIGHT SIMULATOR COMPLEX
J. M. KEIRL 1991 7 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 5: Flight Simulation 1)
(CONGRESS PAPER C428-5-025; HTN-95-21110) Copyright

Piloted, real-time flight simulation is a cost effective tool for the research and development of aircraft and their sub-systems. The research flight simulation complex at DRA Bedford, offers designers a representative environmnet in which to investigate the dynamic interaction between the pilot and the aircraft. This paper describes this facility and recent improvements including the commissioning and integration of a large displacement motion platform. Author (Hemer)

A95-91681
GENERAL REQUIREMENTS FOR THE ELECTROHYDRAULIC SYSTEMS OF THE AIRCRAFT CONTROLS LOADING FORCE ON THE SIMULATORS
A. N. PREDTECHENSKY, V. V. RODCHENKO, YU. P. YASHIN, and L. E. ZAYCHIK 1991 6 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 5: Flight Simulation 1)
(CONGRESS PAPER C428-5-138; HTN-95-21112) Copyright

The paper gives the foundations to the requirements to the electrohydraulic controls loading system (ECLS) which are now widely used on flight and research simulators. The criteria are developed for assessing the influence of different loading characteristics on flying qualitites. The requirements to the ranges of varying basic loading characteristics of different controls are formulated along with requirements to the completeness of their representation by the universal ECLS. Human tresholds to the force variation are studied, and the requirements to the accuracy of the force representation for different controls are developed on the basis of these data. The effect of time-sampling character of the computer operation on the ECLS quality is analysed, and the requirements to the sample time and quantization level are formulated. Author (Hemer)

A95-91698
THE SAAB-SCANIA APPROACH TO DEVELOPMENT SIMULATORS
B. LITTKE Saab-Scania AB, Sweden and G. LINDGREN Saab-Scania AB, Sweden 1991 8 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 10: Flight Simulation 2)
(CONGRESS PAPER C428-10-137; HTN-95-21129) Copyright

In this paper we present the Saab Aircraft Division approach to simulators for aircraft development, primarily for the current projects, the JAS 39 Gripen and the 37 Viggen on the military side and the Saab 340 and Saab 2000 on the commercial side. The Simulation Center is responsible for building and maintaining the simulators for these projects and for delivering results in different forms from real-time flight simulation. Our closest customers are the engineers responsible for the specific functions in the aircraft. Most of our simulators are designed to include aircraft hardware. Much of the effort is spent in supplying signals to this hardware, to create a signal environment which is identical to that in the aircraft. The types of testing performed in the simulators can be split into the catgories of prototyping, integration, verification, and validation. Some of these areas lend themselves to automation. Present work at the Simulation Center includes automation of simulator validation of the flight control system, and standarization of operator/simulator interface through the use of workstations. Author (Herner)

N95-29468# Polytechnic Univ., Farmingdale, NY.
RESEARCH INSTRUMENTATION FOR POLYTECHNIC UNIVERSITY'S SUPERSONIC WIND TUNNEL FACILITY Final Report, 15 Sep. 1993 - 14 Sep. 1994
IRAJ M. KALKHORAN and M. V. OTUGEN 8 Nov. 1994 20 p
(Contract(s)/Grant(s): F49620-93-1-0588)
(AD-A290232; POLY-AE-94-02; AFOSR-95-0048TR) Avail: CASI HC A03/MF A01

Modern instrumentation was acquired for use in Polytechnic University's Supersonic wind tunnel facility. The equipment is currently being incorporated in several on-going research projects dealing with development of non-intrusive measurement techniques, flow visualization, and pressure measurements in high speed unsteady flows. The major components of the research instrumentation include a Q-Switched ND:YAG laser, a CCD camera system with necessary hardware and software and a 16 channel data acquisition and control system with appropriate hardware and software. This report describes the basic function of the acquired equipment and the anticipated use of the equipment for conducting supersonic wind tunnel testing. DTIC

N95-29795 Stanford Univ., CA.
A METHOD FOR THE MODELLING OF POROUS AND SOLID WIND TUNNEL WALLS IN COMPUTATIONAL FLUID DYNAMICS CODES Ph.D. Thesis
THOMAS JOHN BEUTNER 1994 126 p
Avail: Univ. Microfilms Order No. DA9414538

Porous wall wind tunnels have been used for several decades and have proven effective in reducing wall interference effects in both low speed and transonic testing. They allow for testing through Mach 1, reduce blockage effects and reduce shock wave reflections in the test section. Their usefulness in developing computational fluid dynamics (CFD) codes has been limited, however, by the difficulties associated with modelling the effect of a porous wall in CFD codes. Previous approaches to modelling porous wall effects have depended either upon a simplified linear boundary condition, which has proven inadequate, or upon detailed measurements of the normal velocity near the wall, which require extensive wind tunnel time and instrumentation. The current work was initiated in an effort to find a simple, accurate method of modelling a porous wall boundary condition in CFD codes. The development of such a method would allow data from porous wall wind tunnels to be used more readily in validating CFD codes. This would be beneficial when transonic validations are desired, or when large models are used to achieve high Reynolds numbers in testing. A computational and experimental study was undertaken to investigate a new method of modelling solid and porous wall boundary conditions in CFD codes. The method utilizes experimental measurements at the walls to develop a flow field solution based on the method of singularities. This flow field solution was then imposed as a pressure boundary condition in a CFD simulation of the internal flow field. The effectiveness of this method in describing the effect of porosity changes on the wall was investigated. Also, the effectiveness of this method when only sparse experimental measurements were available has been investigated. The current work demonstrated this approach for low speed flows and compared the results with experimental data obtained from a heavily instrumented variable porosity test section. The approach developed was simple, computationally inexpensive, and does not require extensive or intrusive measurements of the boundary conditions during the wind tunnel test. It may be applied to both solid and porous wall wind tunnel tests. Dissert. Abstr.

N95-29967# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
EVALUATION OF RETRO-REFLECTIVE BEADS IN AIRPORT PAVEMENT MARKINGS Final Report
KEITH W. BAGOT Dec. 1994 66 p
(AD-A291065; DOT/FAA/CT-94/120) Avail: CASI HC A04/MF A01

This report identifies the results of a 1-year comparative evaluation on the use of retro-reflective glass beads in airport surface pavement markings. Class beads meeting Federal Specification TT-B-1325B, Type 1 and 3 were tested at three airports for retro-reflectivity, effects on runway friction, conspicuity, and durability. The three test airports were Atlantic City, Greater Pittsburgh, and Phoenix Sky Harbor International airports. Data from this study show the use of beaded materials in airport markings increased the conspicuity and quality of the airport markings. Also discovered in this evaluation was the friction enhancement gained from the incorporation of beads and silica additives into the paint materials. As a result of the findings of this study, certain modifications are recommended for the two existing specifications regarding airport pavement markings, AC 150/5370-IOA, Standards for Specifying Construction on Airports and AC 150/5340-1G Standards for Airport Markings. DTIC

N95-30067*# NYMA, Inc., Brook Park, OH.
A PC PROGRAM FOR ESTIMATING MEASUREMENT UNCERTAINTY FOR AERONAUTICS TEST INSTRUMENTATION Final Contractor Report
PHILIP Z. BLUMENTHAL Cleveland, OH NASA Jul. 1995 16 p
Presented at the 31st Joint Propulsion Conference, San Diego, CA, 10-12 Jul. 1995; sponsored by AIAA, ASME, SAE, and ASEE
(Contract(s)/Grant(s): NAS3-27186; RTOP 505-62-82)
(NASA-CR-198361; E-9759; NAS 1.26:198361; AIAA PAPER 95-3072) Avail: CASI HC A03/MF A01

A personal computer program was developed which provides aeronautics and operations engineers at Lewis Research Center with a uniform method to quickly provide values for the uncertainty in test measurements and research results. The software package used for performing the calculations is Mathcad 4.0, a Windows version of a program which provides an interactive user interface for entering values directly into equations with immediate display of results. The error contribution from each component of the system is identified individually in terms of the parameter measured. The final result is given in common units, SI units, and percent of full scale range. The program also lists the specifications for all instrumentation and calibration equipment used for the analysis. It provides a presentation-quality printed output which can be used directly for reports and documents. Author

N95-30228*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NUMERICAL SIMULATIONS OF THE FLOW IN THE HYPULSE EXPANSION TUBE
GREGORY J. WILSON, MYLES A. SUSSMAN, and ROBERT J. BAKOS (General Applied Science Labs., Inc., Ronkonkoma, NY.) Jun. 1995 53 p
(Contract(s)/Grant(s): RTOP 505-70-62)
(NASA-TM-110357; A-950072; NAS 1.15:110357) Avail: CASI HC A04/MF A01

Axisymmetric numerical simulations with finite-rate chemistry are presented for two operating conditions in the HYPULSE expansion tube. The operating gas for these two cases is nitrogen and the computations are compared to experimental data. One test condition is at a total enthalpy of 15.2 MJ/Kg and a relatively low static pressure of 2 kPa. This case is characterized by a laminar boundary layer and significant chemical nonequilibrium in the acceleration gas. The second test condition is at a total enthalpy of 10.2 MJ/Kg and a static pressure of 38 kPa and is characterized by a turbulent boundary layer. For both cases, the time-varying test gas pressure predicted by the simulations is in good agreement with experimental data. The computations are also found to be in good agreement with Mirels' correlations for shock tube flow. It is shown that the nonuniformity of the test gas observed in the HYPULSE expansion tube is strongly linked to the boundary layer thickness. The turbulent flow investigated has a larger boundary layer and greater test gas nonuniformity. In order to investigate possibilities of improving expansion tube flow quality by reducing the boundary layer thickness, parametric studies showing the effect of density and turbulent transition point on the test conditions are also presented. Although an increase in the expansion tube operating pressure level would reduce the boundary layer thickness, the simulations indicate that the reduction would be less than what is predicted by flat plate boundary layer correlations. Author

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A95-87373
ORBITAL TRANSPORT: TECHNICAL, METEOROLOGICAL AND CHEMICAL ASPECTS; AEROSPACE SYMPOSIUM, 3RD, BRAUNSCHWEIG, GERMANY, AUG. 26-28, 1991
H. OERTEL, JR., editor Technische Universitat Braunschweig, Braunschweig, Germany and H. KORNER, editor Institut fuer Entwurfsaerodynamik, Braunschweig, Germany Berlin, Germany Springer-Verlag 1991 471 p.
(ISBN 3-540-563180; HTN-95-92557) Copyright

A recent aerospace symposium produced 35 papers in the areas of new Orbital transportation systems and technologies, reentry physics and trajectories, precision navigation systems, hypersonic aerodynamics, stratospheric chemistry, and environmental impacts. For individual titles, see A95-87374 through A95-87408. Herner

A95-87379
HIGH TEMPERATURE ASPECTS OF THE EUROPEAN HERMES PROGRAMS
D. ISAKEIT European Space Agency, Paris, France *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 83-102
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The European Space Agency's (ESA) program for the development of the Hermes spaceplane is the first program in Europe dealing with hypersonics on a complex shape. Aerodynamics and aerothermodynamics, particularly with respect to the hot hypersonic flight regime, as well as structures and thermal protection techniques, are among the most important technologies for Hermes. Since the beginning of the Hermes development program, a highly intensive effort in these areas has been undertaken. The effort in the aerodynamical field covered the modelization of the chemical and physical phenomena, computational fluid dynamics (CFD) calculations of increasing complexity, and experimental simulations in various types of wind tunnels and other test facilities. In the field of hot structures and thermal protection, new concepts have been developed. They led to the build-up of new high temperature test facilities in Europe. The present paper presents the main results obtained in high temperature related technologies during the Hermes development phase 1 and points out further efforts which remain to be done in this field. Author (Herner)

A95-87380
THE AEROTHERMODYNAMIC VALIDATION REENTRY EXPERIMENT HYPERBA
H. OERTEL, JR. Technical University of Braunschweig, Braunschweig, Germany *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 103-128
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In this article, the gas kinetic and continuum-mechanical simulation methods along the reentry trajectory of a reusable reentry vehicle will be introduced. First approaches to gas-surface interaction modeling, on the basis of earlier reentry technology programs, will be described. The article demonstrates that a 'Reentry Freeflight Database' is required for the final selection of the gas kinetic and continuum-mechanical 'multi-temperature models' and the determination of relevant model constants. Together with partial validation experiments in wind-tunnels, the same free-flight database is utilized for the final verification of the aerothermodynamic model and model constants. With respect to the scientific goals, the aerothermodynamic validation strategy, HYBERBA, was developed and its practical realization will be demonstrated in the course of the first German-Japanese reentry capsule project, EXPRESS. An extended version of this article with a detailed description of aerothermodynamic methods and phenomena will be published as a text book. Author (revised by Herner)

A95-87382
DESIGN OPTIMIZATION OF AN AIRBREATHING AEROSPACEPLANE
R. JANOVSKY Institute of Aeronautics and Astronautics, Aachen, Germany and R. STAUFENBIEL Institute of Aeronautics and Astronautics, Aachen, Germany *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 149-163
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A new species of advanced space transportation vehicles, called aerospaceplanes, is under discussion, and challenging technology programs are on the way. These vehicles rely on airbreathing propulsion, which, compared to rocket propulsions, provides much higher overall efficiency. Aerospaceplanes will be able to take off and land horizontally and are partly or fully reusable. For this new kind of transportation system, the application of new design principles is necessary. Complex airbreathing propulsion systems have to be integrated into the airframe. Compared to conventional rocket systems, a spaceplane has to stand higher aerodynamic and thermodynamic loads during the longer flight in a denser atmosphere. Therefore, the empty mass fraction of an aerospaceplane will be higher than that of a rocket system and will partly compensate for the higher propulsion efficiency. In this paper, the influence of the key design parameters on the transport efficiency will be determined for the first stage of a two-stage-to-orbit spaceplane with an airbreathing first stage. The configuration of the first stage is a special lifting body, called 'ELAC I'. As a measure of transport efficiency, the ratio of the vehicle take-off mass to payload mass, the so called Growth Factor, is chosen. Furthermore, the design of the first stage is optimized by using a multidimensional optimization procedure to obtain a minimum Growth Factor for various size ratios between the second and first stages. Author (Herner)

A95-87383
INTEGRATED THERMAL AND MECHANICAL ANALYSIS OF HYPERSONIC VEHICLES BY USING ADAPTIVE FINITE ELEMENT METHODS
M. HAUPT Technical University of Braunschweig, Braunschweig,

Germany, H. KOSSIRA Technical University of Braunschweig, Braunschweig, Germany, and J. PLEITNER Technical University of Braunschweig, Braunschweig, Germany *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 165-177 Research sponsored by DFG
Copyright

The topic of this paper is the strategy of an integrated thermal and mechanical analysis of structures subjected to mechanical and aerothermal loads during hypersonic flight. The strategy, based on the finite element method, includes the effects of heat transfer and nonlinearities of the mechanical system. The efficiency of this finite element approach is increased by using adaptive grids and sophisticated nonlinear solution algorithms. The features of this finite element tool are demonstrated by examples of instationary and nonlinear problems. Author (Herner)

A95-87386
VERIFICATION OF ENGINEERING METHODS OF AERODYNAMICS FOR REENTRY VEHICLES BY DSMC
M. S. IVANOV Institute of Theoretical and Applied Mechanics, Novosibirsk, Russia, M. BITZER Institute of Fluid Mechanics, Braunschweig, Germany, and D. HAFERMANN Institute of Fluid Mechanics, Braunschweig, Germany *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 201-212
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A possibility for the improvement of approximate engineering-methods for rarefied gas dynamics is presented. Confidence in the prediction of aerodynamic characteristics can be increased by verification of the engineering methods with Direct Simulation Monte Carlo (DSMC)-calculations. Such a procedure will be demonstrated for various configurations, e.g. the reentry-probes BREMSAT and EXPRESS. Finally, an outlook on the research will be given, which will be required to apply DSMC-methods directly in the design process. Author (Herner)

A95-87387
NUMERICAL MODELING AND SIMULATION OF CHEMICALLY REACTING REENTRY FLOWS
E. LAURIEN Technical University of Braunschweig, Braunschweig, Germany, M. BOHLE Technical University of Braunschweig, Braunschweig, Germany, H. HOLTHOFF Technical University of Braunschweig, Braunschweig, Germany, and J. WIESBAUM Technical University of Braunschweig, Braunschweig, Germany *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 213-222
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The hypersonic flow along the heat-shield of reentry capsules involves strong shocks and high temperatures at low air density. This study outlines the development of a three-dimensional shock-capturing numerical algorithm to simulate such a flow along a reentry trajectory. The continuum model used presents a coupling of aerothermodynamical conservation equations with air chemistry at high temperatures. A simulation algorithm on the basis of the Taylor-Galerkin finite-element method using unstructured numerical grids has been developed. The paper gives a status report on progressing work of the present group. Two- and three-dimensional flow simulations around a blunt body in chemical equilibrium or thermal nonequilibrium are presented. The impact of high temperature aerothermodynamics and air chemistry on the flow under selected parameters are elucidated. The current work makes an attempt to simulate reentry flows along the reentry trajectory with the aim of providing data for design studies and environmental investigations. Author (Herner)

A95-87394
REENTRY TRAJECTORIES AND THEIR OPTIMIZATION BY AN EVOLUTION ALGORITHM
A. BADE Technical University of Braunschweig, Braunschweig, Germany, S. VOEGT Technical University of Braunschweig, Braunschweig, Germany, J. K. AXMANN Technical University of Braunschweig, Braunschweig, Germany, and D. REX Technical University of Braunschweig, Braunschweig, Germany *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 301-310
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The descent of a winged space vehicle from an orbit and the following re-entry into denser atmospheric layers is a rather complex physical process. To get insight into some of the fundamental phenomena, as a first step, the re-entry of simple shaped bodies has to be simulated. In order to improve the understanding of the physics, in this paper, a stepwise approach is presented: re-entry of balls, of capsules and of winged vehicles. For the re-entry of winged space vehicles, the equations of motion are not formulated in Keplerian elements but in earth-oriented coordinate systems, with the help of spherical polar coordinates in the most general form. They include thrust and aerodynamic forces (in three components). The atmosphere is regarded as fixed with the rotating oblate earth. This set of differential equations is solved by numerical integration. The influence of the angle of attack and of the bank angle upon the re-entry trajectory is discussed, also with respect to constraints (e.g., surface temperature). In all practical applications, various optimization problems arise, e.g. if for a required lateral range the heat load for the vehicle has to be minimized. The Institute of Space Technology and Reactor Technology has developed a method based on the evolution strategy, which will shortly be described here. Optimal re-entry trajectories for a preliminary configuration similar to HORUS are presented. Author (Herner)

A95-87396
OPTIMAL SEPARATION AND ASCENT OF LIFTING UPPER STAGES
G. SACHS Technical University of Munich, Muenchen, Germany, W. SCHODER Technical University of Munich, Muenchen, Germany, and J. DREXLER Technical University of Munich, Muenchen, Germany *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 325-333
Copyright

The separation flight maneuver of a lifting upper stage and the ascent following pose new control and optimization problems in flight dynamics of hypersonic vehicles. The mathematical modeling used for both flight tasks are described and optimization techniques applied are addressed. It is shown how the separation maneuver can be optimally controlled for maximizing the translational displacement between both vehicles in the initial phase following release of the upper stage. Safety considerations are taken into account in order to avoid the rear of the upper stage from approaching the first stage due to improper rotation. The ascent of the upper stage is optimized for a maximum final mass in orbit. The effect of initial conditions is considered, with particular reference made to a small flight path inclination at the beginning of an ascent and to the influence exerted by the lifting capability of the upper stage. The final part deals with combining the separation maneuver and the ascent. Thus, the optimal overall performance can be determined and the maximized final mass in orbit can be computed, with the separation maneuver included. Author (Herner)

A95-87483
THE METHANE-ACETYLENE CYCLE AEROSPACE PLANE: A POTENTIAL OPTION FOR INEXPENSIVE EARTH TO ORBIT TRANSPORTATION
ROBERT M. ZUBRIN Martin Marietta Astronautics, Denver, CO, US

British Interplanetary Society, Journal (ISSN 0007-094X) vol. 47, no. 6 June 1994 p. 241-244
(HTN-95-51845) Copyright

Methane, a cheap, soft cryogen with six times the density of hydrogen could be an ideal fuel for use in a hypersonic aerospace plane. However, it does not burn fast enough for efficient scramjet operation and it possesses an inadequate thermal heat sink to cool the aircraft effectively. This paper proposes a concept, termed the Methane-Acetylene Cycle Aerospace Plane (MACASP), that may overcome these difficulties. In the MACASP concept, methane fuel is run out within the wing leading edge in pipes which are allowed to rise in temperature to about 1800 K. Drag heating is used to drive the highly endothermic chemical reaction; $2CH_4 = 3H_2 + C_2H_2$. The reaction occurs on a millisecond time scale and endows the methane with a heat sink per unit mass comparable to that possessed by liquid hydrogen. The reaction products are fed into a combustion chamber and burned in air, releasing as much energy per unit mass at as rapid a combustion rate as hydrogen. This paper explores the thermodynamics of the MACASP concept and theoretical feasibility is demonstrated. Potential problems and areas of concern are identified. A conceptual point design for a MACASP vehicle is advanced and mission analysis performed comparing the MACASP to a conventional hydrogen aerospace plane. It is shown that the MACASP concept offers significant promise for economical Earth to orbit transportation. Author (Herner)

A95-88601

SEPARATION OF WINGED VEHICLES IN SUPERSONICS

T. BONNEFOND Aerospatiale Espace & Defense, Les Mureaux, France, A. M. KHARITONOV ITAM, Novosibirsky, Russia, M. D. BRODETSKY ITAM, Novosibirsky, Russia, L. G. VASENYOV ITAM, Novosibirsky, Russia, N. P. ADAMOV ITAM, Novosibirsky, Russia, and E. K. DERUNOV ITAM, Novosibirsky, Russia 1995 10 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chatanooga, TN, April 3-7, 1995
(AIAA PAPER 95-6092; HTN-95-00891) Copyright

The aim of this paper is to present the aerodynamic interferences occurring during the separation of two vehicles at supersonic speeds. After a description of the flowfield structure between the two stages, an experimental study prepared in cooperation between AEROSPATIALE and the Institute of Theoretical and Applied Mechanics (ITAM), Russian Academy of Sciences, Siberian Division and performed in the T-313 facility at ITAM is presented, including the justification of the models and test conditions. Results are then presented concerning both wall pressure measurements on the models and global aerodynamic coefficients of the two stages (drag, lift and pitching moment). Some comparisons with computations are also shown. Shortcomings of the present study are given in a last part, together with possible future complementary activities on this topic. Author (Herner)

A95-90360

A LOW FIN HEIGHT HEAT EXCHANGER TECHNOLOGY DEMONSTRATOR FOR HERMES

ALBERTO PAVARANI, STANLEY WALMSLEY, and MAURIZIO PETRUZZIELLO (ISSN 0148-7191) 1993 10 p. 23rd International Conference on Environmental Systems, Colorado Springs, Colorado, July 12-July 15, 1993
(SAE PAPER 932119; HTN-95-20983) Copyright

The stringent mass targets of the Hermes spaceplane require the design of extremely compact plate & fin heat exchangers (HXs), hence with a very low fin height, operating at low Reynolds numbers. A program, involving the design, manufacture and performance testing of a HX representative of the Hermes Interloop Heat Exchanger requirements, has been set up in order to explore manufacturing difficulties associated with such low height fins and to verify by test the fin thermohydraulic performance. This paper describes in detail the Technology Demonstator design criteria, the test set-up and the test results obtained. Author (revised by Herner)

A95-91544

MULTIOBJECTIVE TRAJECTORY OPTIMIZATION BY GOAL PROGRAMMING WITH FUZZY DECISION

SHINJI SUZUKI Tokyo Univ., Japan and TAKESHI YOSHIZAWA Tokyo Univ., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 374-377 In JAPANESE
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A sequential goal programming approach is presented to solve flight trajectory problems. Using a time integration algorithm, trajectory optimization problems were transformed into nonlinear optimization problems in terms of finite control variables at discrete time points. By regarding both the performance index and the design constraints as goals to be achieved and by prioritizing each goal, goal programming (GP) formulation can solve these optimal problems. In trajectory problems having multiobjectives such as the fuel consumption minimization and the final time minimization, a fuzzy decision making method is applied for the conflicting goals. The accuracy of the present method's solution is shown in a simple ascent trajectory problem having the analytical solutions. Finally, the method is applied to a flight path optimization of a jet-transport. Author (Herner)

A95-91549

A GUIDANCE CONCEPT FOR HYPERSONIC AEROSPACECRAFTS

SHINJI ISHIMOTO Tokyo Univ., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 402-405 In JAPANESE
Copyright

In this paper a guidance concept for hypersonic re-entry flights is presented. The method uses a closed-form guidance technique based on a drag acceleration reference profile. A guidance law for range control is developed. It employs a physical relation between vehicle energy and range instead of a prediction-correction technique used for Shuttle entry guidance. Simulation results show that the algorithm provides good performance. Author (Herner)

A95-91550

OPTIMALITY OF THE STEADY-STATE FLIGHT FOR HYPERSONIC AIRCRAFT

SEIYA UENO Yokohama National Univ., Yokohama, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 406-409 In JAPANESE
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Periodic control which repeats the same sequence of control can reduce fuel consumption for cruising aircraft. In this paper, this type of control is applied to hypersonic airplanes, and the comparison between steady flights and unsteady ones is shown numerically. The optimal thrust is bang-bang controlled. The results show that the unsteady optimal path exists around the steady one and reduces not only fuel consumption but also flight time. Author (Herner)

N95-29339*# Georgia Inst. of Tech., Atlanta, GA. School of Aerospace Engineering.

ANALYTICAL INVESTIGATIONS IN AIRCRAFT AND SPACECRAFT TRAJECTORY OPTIMIZATION AND OPTIMAL GUIDANCE Final Report

NIKOS MARKOPOULOS and ANTHONY J. CALISE May 1995 187 p
(Contract(s)/Grant(s): NAG1-922; NAG1-1257; RTOP 242-80-01-02)
(NASA-CR-4672; NAS 1.26:4672) Avail: CASI HC A09/MF A02

A collection of analytical studies is presented related to unconstrained and constrained aircraft (a/c) energy-state modeling and to spacecraft (s/c) motion under continuous thrust. With regard to a/c unconstrained energy-state modeling, the physical origin of the singular perturbation parameter that accounts for the observed 2-time-scale behavior of a/c during energy climbs is identified and explained. With regard to the constrained energy-state modeling, optimal control problems are studied involving active state-variable inequality constraints. Departing from the practical deficiencies of the control programs for such problems that result from the traditional formulations, a complete reformulation is proposed for these problems which, in contrast to the old formulation, will presumably lead to practically useful controllers that can track an inequality constraint boundary asymptotically, and even in the presence of 2-sided perturbations about it. Finally, with regard to s/c motion under continuous thrust, a thrust program is proposed for which the equations of 2-dimensional motion of a space vehicle in orbit, viewed as a point mass, afford an exact analytic solution. The thrust program arises under the assumption of tangential thrust from the costate system corresponding to minimum-fuel, power-limited, coplanar transfers between two arbitrary conics. The thrust program can be used not only with power-limited propulsion systems, but also with any propulsion system capable of generating continuous thrust of controllable magnitude, and, for propulsion types and classes of transfers for which it is sufficiently optimal the results of this report suggest a method of maneuvering during planetocentric or heliocentric orbital operations, requiring a minimum amount of computation; thus uniquely suitable for real-time feedback guidance implementations. Author

N95-29351*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
BIBLIOGRAPHY OF DOCTOR CHUL PARK
LAWRENCE A. GOCHBERG (National Academy of Sciences - National Research Council, Moffett Field, CA.), ETHIRAJ VENKATAPATHY (Thermoscience Inst., Moffett Field, CA.), and CHUL PARK May 1995 180 p
(Contract(s)/Grant(s): RTOP 242-10-80)
(NASA-TM-110353; A-950065; NAS 1.15:110353) Avail: CASI HC A09/MF A02

This document contains a comprehensive bibliography of the published works, and a short biography, of Dr. Chul Park. The contents of this bibliography were compiled primarily from the NASA RECON data base. The RECON citations have been modified to appear in a uniform format with all other listed citations. These other citations were located by computer searches in the INSPEC, NTIS, COMPENDEX, and Chemical Abstracts data bases, as well as through the cooperation of Dr. Chul Park, and his associates in the Reacting Flow Environments Branch at NASA Ames Research Center. All citations are presented in an approximate reverse chronological order from the present date. This work was created to honor the occasion of Dr. Chul Park's retirement on December 14, 1994, after 27 years of distinguished government service at the NASA Ames Research Center. Author

N95-29447*# Draper (Charles Stark) Lab., Inc., Cambridge, MA. EG/Aeroscience and Flight Mechanics Div.
A VEHICLE HEALTH MONITORING SYSTEM FOR THE SPACE SHUTTLE REACTION CONTROL SYSTEM DURING REENTRY M.S. Thesis - Massachusetts Inst. of Technology
ANTHONY DAVID ROSELLO 22 May 1995 120 p
(Contract(s)/Grant(s): NAS9-18426)
(NASA-CR-188370; NAS 1.26:188370; CSDL-T-1250) Avail: CASI HC A06/MF A02

A general two tier framework for vehicle health monitoring of Guidance Navigation and Control (GN&C) system actuators, effectors, and propulsion devices is presented. In this context, a top level monitor that estimates jet thrust is designed for the Space Shuttle Reaction Control System (RCS) during the reentry phase of flight. Issues of importance for the use of estimation technologies in vehicle health monitoring are investigated and quantified for the Shuttle RCS demonstration application. These issues include rate of convergence, robustness to unmodeled dynamics, sensor quality, sensor data rates, and information recording objectives. Closed loop simulations indicate that a Kalman filter design is sensitive to modeling error and robust estimators may reduce this sensitivity. Jet plume interaction with the aerodynamic flowfield is shown to be a significant effect adversely impacting the ability to accurately estimate thrust. Author

N95-29794 Stanford Univ., CA.
DC ELECTROSTATIC GYRO SUSPENSION SYSTEM FOR THE GRAVITY PROBE B EXPERIMENT Ph.D. Thesis
CHANG-HUEI WU 1994 149 p
Avail: Univ. Microfilms Order No. DA9414678

The Gravity Probe B experiment is a satellite-based experiment primarily designed to test two aspects of Einstein's General Theory of Relativity by observing the spin axis drift of near-perfect gyroscopes in a 650-km circular polar orbit. The goal of this experiment is to measure the drift angles to an accuracy of 0.3 milli-arcsec after one year in orbit. As a result, electrostatically suspended free-spinning gyroscopes operating at a very low temperature became the final choice for their ultra-low Newtonian torque-induced drift rate. The Conventional AC current-driven suspension system faces two fundamental difficulties for ground gyro testing. Field emission causes rotor charging and arcing with an imperfect electrode or rotor surfaces because the electric field intensity needed to support a solid rotor in the 1-g field is more than 107 V/m. The system not only becomes unstable at a high rotor charge, which can be more than 500 volts, but may also lose control in case of arcing. Both the high voltage AC suspension signal and the high frequency (1 MHz) signal for rotor position sensing interfere with the superconducting SQUID magnetometer for spin axis readout through inductive coupling. These problems were resolved by using DC voltage to generate a suspension force and a low frequency position sensor. In addition to the Input/Output linearization algorithm developed to remove the system nonlinearity for global stability and dynamic performance, we also minimized the electric field intensity to reduce rotor charging. Experimental results verified the desired global stability and satisfactory dynamic performance. The problem of rotor charging is virtually eliminated. More importantly, the DC system is compatible with the SQUID readout system in the Science Mission configuration. Consequently, experiments in low magnetic field at a sub-micro-gauss level for SQUID design verification and trapped flux distribution study were finally realizable in ground environment. The second part of the research focused on design issues for the Science Mission in a micro-g environment. The unique requirement of the GP-B experiment is to minimize suspension-induced torque and subsequent spin axis drift. A nonlinear control law which employs stiffened spring and stiffened damping coefficients was developed to achieve both low RMS noise in steady-state operation and quick response for situations like a micrometeoroid impact. Rotor voltage measurement and in-flight sensor bias correction schemes were developed to ensure system stability and absolute centering accuracy. Simulation results verified the system performances and confirmed that a suspension system induced rotor spin axis drift lower than 0.1 milli arcsec/year can be reached. Dissert. Abstr.

11

CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A95-87285
HIGH PRESSURE VAPORIZATION AND BURNING OF METHANOL DROPLETS IN REDUCED GRAVITY
C. CHAUVEAU Centre National de la Recherche Scientifique, Orleans, France, X. CHESNEAU Centre National de la Recherche Scientifique, Orleans, France, and I. GOKALP Centre National de la Recherche Scientifique, Orleans, France Microgravity sciences: Results and analysis of recent spaceflights; Symposium G1 of COSPAR Scientific Assembly, 30th, Hamburg, Germany, July 11-21, 1994. A95-87258 Advances in Space Research (ISSN 0273-1177) vol. 16, no. 7 1995 p. (7)157-(7)160 Research sponsored

by the CNRS/CNES, and the European Space Agency Microgravity Program
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In the work described here, emphasis is put on recent results obtained in high pressure methanol droplet vaporization and burning experiments conducted both under normal gravity and during the parabolic flights of the CNES Caravelle. The combination of high ambient pressure droplet burning experiments with reduced gravity is crucial in order to reduce the pressure enhanced natural convection effects and also to extend the applicability of the fiber suspended droplet technique when the surface tension decreases due to the closeness of thermodynamic critical conditions. Low temperature vaporization experiments are conducted in dry air up to 10 MPa, but only under normal gravity conditions because of the longer gasification times. Droplet burning experiments are conducted up to 8 MPa under normal gravity and up to 5 MPa under reduced gravity. The pressure dependencies of the gasification rates for each regime are discussed. Author (Herner)

A95-87566
MULTIDIMENSIONAL CALCULATION OF SPARK FLAME INITIATION BY ADOPTING A GENERIC HYDROCARBON KINETIC SCHEME
R. TATSCHL Fluid Dynamics Research Dept., Graz, Austria and W. BRANDSTATTER Fluid Dynamics Research Dept., Graz, Austria *In* Computational methods in applied sciences; European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sept. 7-11, 1992. A95-87552 Amsterdam, The Netherlands Elsevier Science Publishers B.V. 1992 p. 283-293
Copyright

The application of a mathematical reactive-flow model, consisting of a reduced chemical kinetic reaction scheme coupled with a multidimensional fluid-dynamic method, to the simulation of spark ignition and flame kernel propagation in premixed, gaseous mixtures of hydrocarbon-fuel and air is described. The kinetic scheme is based on a reaction mechanism originally developed for the study of autoignition phenomena of hydrocarbon-fuels under engine-like conditions. This model, employing so-called generic chemical species, has been basically modified for the primary purpose of simulating the spark flame initiation and propagation phenomena. The capability of the mathematical model to predict the fluid-dynamic features and reaction trends of the spark ignition and flame propagation processes is assessed through application of the method to two test-case studies. In these, the effect of different spark discharge characteristics on the flame initiation and propagation in a constant volume combustion chamber is numerically examined, and the results thus obtained are checked against the corresponding experimental data. The comparison of the numerical results with the experimental shows good agreement and provides evidence that the model is capable of predicting the spark flame initiation and propagation process and the associated fluid-dynamic phenomena. Author (Herner)

A95-87605
BUCKLING AND POSTBUCKLING OF COMPOSITE STRUCTURES
K. A. STEVENS Imperial College of Science, Technology and Medicine, London, UK, R. RICCI Imperial College of Science, Technology and Medicine, London, UK, and G. A. O. DAVIES Imperial College of Science, Technology and Medicine, London, UK Composites (ISSN 0010-4361) vol. 26, no. 3 March 1995 p. 189-199 Research sponsored by EEC Brite Euram Directive
(HTN-95-71387) Copyright

The postbuckling behavior of a flat, stiffened, carbon fiber composite compression panel has been studied, theoretically and experimentally. The panel had a collapse load in excess of three times the bucklingload. An initial failure mechanism leading to eventual explosive collapse of the panel is idenitified and the damaging stress resultant is measured in the panel and predicted from a finite element analysis. Author (Herner)

A95-87606
FAILURE BEHAVIOUR OF CARBON FIBER/EPOXY COMPOSITES IN PIN-ENDED BUCKLING AND BENDING TESTS
K. PADMANABHAN Indian Insititute of Science, Bangalore, India and KISHORE Indian Insititute of Science, Bangalore, India Composites (ISSN 0010-4361) vol. 26, no. 3 March 1995 p. 201-206 Research sponsored by the Council of Scientific & Industrial Research, New Delhi
(HTN-95-71388) Copyright

T300 carbon fiber/epoxy composite specimens with unidirectional and cross-ply orientation and G802 woven fabric/epoxy specimens were tested in a pin-ended rig at various specimen geometries. The rig was designed so that a combination of bending and compression was possible. Failure initiation and failure sequences at the midspan were monitored and established through photography. In some specimen geometries, high compressive strains of the order of approximately 1.85% for pin-ended tests, accompanied by a higher load-bearing capacity than in conventional bend tests, were observed. Fracture characterization and failure analysis were carried out with the aid of a scanning electron microscope. Author (Herner)

A95-88264
EFFECT OF ANNEALING AND DESULFURIZATION ON OXIDE SPALLATION OF TURBINE AIRFOIL MATERIAL
C. L. BRIANT General Electric R&D Cent, Schenectady, NY, United States, W. H. MURPHY, and J. C. SCHAEFFER Scripta Metallurgica et Materialia (ISSN 0956-716X) vol. 32, no. 9 May 1 1995 p. 1447-1451 refs
(BTN-95-EIX95282707024) Copyright

A study that addresses the sulfur-induced spallation theory is reported. Previous study has shown that a high temperature anneal in hydrogen desulfurizes nickel-base alloys and greatly improves their resistance to oxide spallation. In this paper, it is shown that such an anneal can be applied successfully to a Ni-base airfoil material. Both Auger segregation experiments and chemical analyses show that this anneal desulfurizes the material, at least in the absence of yttrium. However, the results suggest that factors other than desulfurization may be contributing to the improvement in spallation resistance produced by the anneal. EI

A95-88496
THE KEY TO DESIGNING DURABLE ADHESIVELY BONDED JOINTS
L. J. HART-SMITH McDonnell Douglas Corp., US Composites (ISSN 0010-4361) vol. 25, no. 9 October 1994 p. 895-898
(HTN-95-12033) Copyright

Service experience with adhesively bonded aircraft structures may be subdivided into two categories — the structures which last forever and about which nobody hears (because there was nothing to report) and those that fall apart far too soon and of which everybody is made aware. The first category proves that the second need not have occurred, while the second category denies further opportunities for repeating the benefits of the first. This paper discusses and outlines the key to designing durable adhesively bonded joints. Author (Herner)

A95-88961
DETERMINATION OF MINIMUM FUEL OCTANE NUMBER PISTON AIRCRAFT ENGINES
ROBERT B. INGRAM Textron-Lycoming, US and BENTON E. VISSER Shell Development Co., US (ISSN 0148-7191) 1993 17 p. SAE General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, KS, May 18-20, 1993
(SAE PAPER 931230; HTN-95-20922) Copyright

The determination of the minimum fuel octane required for an aircraft engine, utilizes detonation equipment and test techniques developed prior to World War II. These procedures were designed to provide a 12% margin of safety on traditionally leaded aviation fuels which met the lean and rich ratings as listed in the applicable American Society for Testing and Materials (ASTM) specification. Now, due to a possible phase out of leaded fuels, it appears necessary for aircraft engine manufacturers and STC applicants to re-evaluate these techniques and procedures to determine if they are applicable for unleaded fuels. And to re-evaluate existing engines to determine the minimum acceptable requirements for a new unleaded aviation gasoline. This paper reviews these techniques and looks at possible requirements for an unleaded aviation gasoline. Author (Herner)

A95-88962

VAPOR LOCK STUDIES FOR GASOLINES WWITH ETHERS

DAVID H. ATWOOD Galaxy Scientific Corp., US and GUS FERRARA FAA Technical Center, US (ISSN 0148-7191) 1993 6 p. SAE General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, KS, May 18-20, 1993

(SAE PAPER 931233; HTN-95-20923) Copyright

A lycoming IO320 aircraft engine was run on different base fuels containing various percentages of methyl tertiary-butyl ether (MTBE). Vapor lock, vapor to liquid ratio (VLR), and Reid vapor pressure (RVP) tests were performed on the fuel mixtures to obtain a method that will provide a measure of the volatility of aircraft fuels for the purpose of aircraft certification. For the vapor lock runs the test fuel was heated to temperatures of 32, 38, 44, and 49 C. A vapor lock run was performed for each combination of fuel mixture and tank temperature at fuel flow rates of 10, 20, 30, 40, 50 and 60 liters per hour. The quickest time to vapor lock was found to be at a fuel temperature of 44 C at takeoff power. The temperature corresponding to a vapor to liquid ratio of 40 is a good indicator of vapor lock behavior of the fuel since it was found to be approximately equal to the average sediment bowl temperature at vapor lock and linearly related to the average time to vapor lock. Author (Herner)

A95-88963

ONGOING RESEARCH INTO HIGH OCTANE UNLEADED AVGAS

AUGUSTO FERRARA FAA Technical Center, US and DAVID H. ATWOOD Galaxy Scientific Corp., US (ISSN 0148-7191) 1993 8 p. SAE General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, KS, May 18-20, 1993

(SAE PAPER 931234; HTN-95-20924) Copyright

This paper addresses on going research that is being conducted by the FAA Technical Center on an unleaded replacement for 100LL aviation gasoline. Topics include preliminary results from performance studies, a survey of commonly found materials in aircraft fuel systems, lab tests which evaluated the effectiveness of several octane enhancers, engine oil analyses, and preliminary results from water contamination and fuel aging studies. This paper also discusses long term plans including: detonation surveys, flight tests, and octane rating of typical aircraft engines. Author (Herner)

A95-89201

POLYMER COMPOSITE APPLICATIONS TO AEROSPACE EQUIPMENT

R. F. J. MCCARTHY Dowty Aerospace Propellers, Gloucester, UK, G. H. HAINES Dowty Aerospace Propellers, Gloucester, UK, and R. A. NEWLEY Dowty Aerospace Propellers, Gloucester, UK Composites Manufacturing (ISSN 0956-7143) vol. 5, no. 2 June 1994 p. 83-93

(HTN-95-B0257) Copyright

This paper describes Dowty's experience in the composite technology areas of designing in composites, materials development, manufacturing using the resin transfer molding (RTM) process, quality assurance and certification which has underpinned the highly successful application of composites in advanced propeller blades. Additional design considerations which must be satisfied to extend the use of composites in other product areas such as multiaxial loading on structural components in landing gear are also addressed. Author (Herner)

A95-89202

STRUCTURAL COMPOSITES IN CIVIL GAS TURBINE AERO ENGINES

JOHN DOMINY Rolls Royce plc, Derby, UK Composites Manufacturing (ISSN 0956-7143) vol. 5, no. 2 June 1994 p. 69-72

(HTN-95-B0258) Copyright

It is now 50 years since materials that we would recognize as modern composites first saw application as aircraft primary structure. There has been major use of composites in gas turbine aero engines since the early 1960s, when parts such as the compressor system in the Rolls-Royce RB108 were manufactured in glass-reinforced plastic. Conventional composite materials offer the designer the potential of strength and high stiffness with light weight. Metal- and ceramic-matrix composites extend this possibility to the higher temperature parts of the engine. In the present generation of gas turbine aero engines composites represent of the order of 10% of the engine weight. Almost all of this is within the nacelle system. The high-thrust engines due to enter service during the 1990s will extend the use into the core engine. If composites are to progress further they must find application in the core structures, where their durability will be critical to the engine. This requires a new level of maturity for both composite materials and the design methodology. The limitation on the rate of progress of composites is the ability to engineer them with confidence and to reliably predict their behavior. This will clearly improve as more composites are used. A growing undertanding of and sympathy for the materials, together with the flair of the designer, will bring about new and innovative applications for composites. Author (Herner)

A95-90120

PLASTER DAMAGE EXPERIMENTS AT THE BBN SONIC BOOM TEST FACILITY

MATTHEW D. SNEDDON BBN Systems and Technologies, Canoga Park, CA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 385-390 Research sponsored by U.S. Air Force

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A series of plaster damage tests has recently been conducted at BBN's Sonic Boom Test Facility. These experiments mark the completion of the first tests performed in this facility, designed to generate sonic boom and other low-frequency signals in a large (up to 30 cubic meters) test volume. These tests were performed as part of a larger study of the potential for cumulative damage effects in structures. The experiments were designed to allow crack formation and crack growth in realistic test samples to be studied in a fully controlled acoustic environment. A set of full-scale plaster test articles were prepared that were representative of typical plaster wall sections, materials, and construction techniques. These articles were exposed to a total of 30,000 sonic booms, at overpressures as great as 1 kPa (20 psf). All test articles were fully instrumented with accelerometers and strain gages. Plaster damage was measured using an innovative remote vision inspection system developed specifically for these experiments. This paper describes the facility, its key features, and the series of plaster damage tests. Author (Herner)

A95-90272

OPTIMAL DESIGN OF COMPOSITE HELICOPTER POWER TRANSMISSION SHAFTS WITH AXIALLY VARYING FIBER LAYUP

MARK S. DARLOW Technion-Israel Institute of Technology, Haifa, Israel and JOSEPH CREONTE Rensselaer Polytechnic Institute, Troy, NY, US American Helicopter Society, Journal (ISSN 0002-8711) vol. 40, no. 2 April 1995 p. 50-56

(Contract(s)/Grant(s): DAAG29-82-K-0093)

(HTN-95-01086) Copyright

The optimal design of supercritical drive shafting was developed with the goal of minimum weight. A numerical optimization scheme was employed to achieve the lightest possible shaft consistent with geometric, strength, and stability constraints. In the initial stage of this research, the use of optimization methods in the design of graphite-epoxy composite power transmission shafts was effectively demonstrated, where the fiber lay-up was held constant over the length of the shaft. This effort investigates the additional benefits associated with allowing the fiber lay-up and thickness to vary as a function of axial position along the shaft. The method was applied to the redesign of tail rotor driveshafts (AH-64 Apache and UH-60 Blackhawk) and synchronization shafts (CH-47 Chinook) to illustrate potential weight savings. The results showed that though dramatic weight savings could be achieved through the use of supercritical composite shafts, it is also possible to design subcritical composite shaft systems that are significantly lighter than current aluminum designs. Author (Herner)

A95-90451

INTERMETALLIC AND TITANIUM MATRIX COMPOSITE MATERIALS FOR HYPERSONIC APPLICATIONS

B. BERTON Dassault Aviation, Saint-Cloud, Frace, G. SURDON Dassault Aviation, Saint-Cloud, Frace, and C. COLIN Aersopatiale Space & Defence, St Medard en Jalles, Frace 1995 9 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995 Research sponsored by Direction de Recherches Etudes et Techniques

(AIAA PAPER 95-6132; HTN-95-B0370) Copyright

As part of the French Program of Research and Technology for Advanced Hypersonic Propulsion (PREPHA) which was launched in 1992 between Aerospatiale, Dassault Aviation, ONERA, SNECMA and SEP, an important work is specially devoted to the development of titanium and intermetallic composite materials for large airframe structures. At Dassault Aviation, starting from a long experience in Superplastic Forming - Diffusion Bonding (SPF-DB) of titanium parts, the effort is brought on the manufacturing and characterization of composites made from Timet beta 21S or IMI 834 foils and Textron SCS6 fiber fabrics. At 'Aersopatiale Espace & Defence', associated since a long time about intermetallic composite materials with university research laboratories, the principal effort is brought on plasma technology to develop the gamma titanium aluminide TiAl matrix composite reinforced by protected silicon carbide fibers (BP SM 1240 or TEXTRON SCS6). The objective, is to achieve, after 3 years of time, to elaborate a medium size integrally stiffened panel (300 x 600 sq mm). Author (Herner)

A95-90475

AEROSPACE APPLICATIONS OF BETA TITANIUM ALLOYS

RODNEY B. ROYER Boeing Commercial Airplane Group, Seattle, Washington, US JOM (ISSN 1047-4838) vol. 46, no. 7 July 1994 p. 20-23

(HTN-95-B0394) Copyright

Beta alloys are beginning to play a significant role in both military and commercial aircraft. Ti-10V-2Fe-3Al forgings, for example play major roles in the McDonnell Douglas C-17 and the Boeing 777. The attractive properties of Beta-C are increasing the use of titanium, rather than steel, in aircraft springs. Ti-15V-3Cr-3Al-3Sn is subject to increasing usage primarily because of its strip productibility and formability. Beta-21S is gaining importance for high-temperature applications. New alloys such as Beta CEZ, SP-700, and Timetal LCB could become important because of advantageous costs, processing, and/or properties. In the past, the use of beta alloys has largely been driven by their superior properties and weight-savings potential. In the future, cost will become more important. As a result, a greater emphasis will be placed on lower cost alloys and/or taking advantage of the improved processing capabilities of these alloys to minimize final component costs. Author (revised by Herner)

A95-90477

ORDERED INTERMETALLIC ALLOYS, PART 3: GAMMA TITANIUM ALUMINIDES

YOUNG-WON KIM UES, Dayton, Ohio, US JOM (ISSN 1047-4838) vol. 46, no. 7 July 1994 p. 30-39

(Contract(s)/Grant(s): F33615-91-C-5563)

(HTN-95-B0396) Copyright

Extensive reserach during the last eight years has resulted in the development and improvement of second-generation gamma alloys of engineering importance, Ti-48-AL-2(Cr or Mn)-2Nb and derivatives. These alloys exhibit properties, in duplex micro-structural forms, meeting requirements for some gas-turbine and automobile engine components that may be used up to 760 C. These achievements were made possible by an improved understanding of both fundamental and practical aspects of these aluminides, such as phase relations, microstructure evolution and control, processing, microstructure-property relationships, and deformation and fracture processes. Nevertheless, widespread higher performance and/or higher-temperature applications of these alloys appear unlikely unless the current properties are dramatically improved. Author (revised by Herner)

A95-91530

EFFECTS OF STRUCTURAL DAMPING ON AEROELASTIC STABILITY OF VARIOUS SHAPED COMPOSITE PLATE WING

KYO-NAM KOO Korea Advanced Inst. of Science and Technology, Republic of Korea and IN LEE Korea Advanced Inst. of Science and Technology, Republic of Korea *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 254-257

Copyright

The structural damping effect on the flutter boundary has been investigated for the three types of wing: rectangular, swept-forward, and swept-back wings. The unsteady aerodynamic loadings on oscillating wings are evaluated by the doublet-point method. The structures of the composite wings are modeled by the shear deformable finite element. The interpolation between the structural and aerodynamic grids is accomplished by using the surface spline. The effects of the composite fiber orientation on the natural frequency and the modal loss factor are studied for the rectangular and swept-back wings. Also, the effects of the fiber orientation on the flutter/divergence characteristics are investigated for three types of wing. The addition of structural damping increases the flutter speeds and decreases the flutter frequencies. Author (Herner)

A95-91570

MECHANICAL PROPERTIES OF ADVANCED TOUGHENED BISMALEIMIDE MATRIX COMPOSITE

MINORU NODA Kawasaki Heavy Industries Ltd., Japan, YASUHIRO ITOH Kawasaki Heavy Industries Ltd., Japan, and SHINICHI MIYAMOTO Kawasaki Heavy Industries Ltd., Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 498-501 In JAPANESE

Copyright

High performance is required at elevated temperatures to apply composite materials to the supersonic transport plane (SST). Bismaleimide (BMI) matrix composites are now in the spotlight because they have higher toughness than that of epoxy and their processibilities are nearly the same as epoxy matrix composites. So, the toughness of BMI has been improved recently. We evaluated the fundamental processibilities and the mechanical properties of BASF-Narmco G40-800/RIGIDITE X5260 as one of the candidate materials for the SST primary structure. This paper presents good processibility, superior damage tolerance and good high temperature performance of this material. Author (Herner)

A95-91659

HIGH HEAT SINK FUELS FOR IMPROVED AIRCRAFT THERMAL MANAGEMENT

W.E. HARRISON, III USAF Wright Laboratory, US, K. E. BINNS USAF Wright Laboratory, US, S.D. ANDERSON USAF Wright Laboratory, US, and R. W. MORRIS USAF Wright Laboratory, US (ISSN 0148-7191) 1993 10 p. SAE, International Conference on Environmental Systems, 23rd, Colorado Springs, CO, July 12-15, 1993

(SAE PAPER 932084; HTN-95-21090) Copyright

Aircraft subsystem and engine heat loads are increasing at a rapid rate. Fuel is used in integated aircraft thermal management systems to cool aircraft subsystems and the engine lubricating oil. All current U. S. fighter aircraft circulate fuel on the airframe to match heat loads with available heat sink. Future aircraft will be required to circulate fuel in excess of that required for propulsive energy through the airframe and engine to assure component life and integrity. These thermal stresses push current fuels JP-4 and JP-8 to bulk fuel temperatures as high as 163 C at the inlet to the mainburner fuel nozzles and to wetted wall temperatures at 206 C inside the fuel nozzle passages. At these conditions, engine fuel nozzles, afterburner spray assemblies and manifolds are plugging, causing increased maintenance and cost.The development of JP-8+100 allows the beginning of an era to develop improved aircraft thermal management schemes that can exploit the 50% increase in fuel heat sink, the higher potential operating temperatures and potentially reduce the amount of fuel recirculated through the aircraft. One concept that offers potential is the hot tank concept. This paper will explore thermal management limitations of JP-8, a summary of the effort to develop JP-8+100, and the potential exploitation of the improved heat sink offered by JP-8+100. Author (Herner)

A95-91675
DAMAGE TO COMPOSITE AIRCRAFT STRUCTURES FROM LIGHTNING STRIKE ATTACHMENT TO UNPROTECTED CFC AND INTERNAL SPARKING CAUSING FUEL INJECTION
G. W. REID and S. J. HAIGH 1991 9 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 4: Damage and Repair)
(CONGRESS PAPER C428-4-026; HTN-95-21106) Copyright

A previous paper given to Aerotech described the overall hazards to modern aircraft structures and systems due to lightning strikes. A more detailed paper outlining the mechanical damage to aircraft structures from lightning strikes was previously given. In this paper we discuss two aspects of the lightening threat to carbon fiber aircraft. The first considers in some detail the degree of physical damage which can occur to an unprotected carbon fiber skin (carbon fibre composite (CFC)) and the second the problem of preventing fuel vapor ignition in composite structures. Author (Herner)

A95-91676
THE RAIN EROSION OF PEEK (POLYETHERETHERKETONE)
P. TATTERSHALL 1991 4 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 4: Damage and Repair)
(CONGRESS PAPER C428-4-039; HTN-95-21107) Copyright

The rain erosion behavior of PEEK, both unreinforced and with the addition of 30% chopped glasss fiber, has been investigated using the RAE Whirling Arm Facility. The unreinforced material exhibited an excellent performance with cracks eventually occuring from the development of overlapping ripple features created by individual impacts. In contrast, the glass reinforced material was subject to weight loss from the start of the application of the rainfield due to the breakage of the suface fibers by individual impacts and the stripping out of matrix from between broken fibers. Suggestions are given for design features to improve the rain erosion performance of reinforced components. Author (Herner)

A95-91677
REPAIRS TO COMPOSITE STRUCTURE ON MILITARY AIRCRAFT
B. E. A. GORDON British Aerospace (MA) Ltd, UK 1991 4 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 4: Damage and Repair)
(CONGRESS PAPER C428-4-067; HTN-95-21108) Copyright

Modern day high performance combat aircraft are using progressively more and more compsite materials as part of the airframe structure to take advantage of their high specific strength and stiffness. Inevitably, damage will occur to these structures, and this paper outlines the techniques that have been developed for the repair of carbon fiber composite materials, discusses their effectiveness, and highlights areas of development for the future. Author (Herner)

A95-91714
INTELLIGENT SKINS DEVELOPMENT FOR FUTURE MILITARY AIRCRAFT
F. M. UNDERWOOD 1991 3 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 17: New Materials and Processes)
(CONGRESS PAPER C428-17-189; HTN-95-21145) Copyright

In order to develop smart structures for introduction into future military aircraft, intelligent skins technology must be developed. The definition of intelligent skins is a composite skin embedded with fiber optics that can be used to sense strain, temperature, pressure and deformation. This paper introduces the concept of smart structures, and the perceived benefits for the aerospace industry. The use of fiber optic sensors for structural health monitoring and impact damage assessment within composite structures are discussed. In addition, the possible savings that can be obtained from embeddiing fiber optic sensors through reduced life cycle costs are highlighted. Author (Herner)

A95-91716
AEROSPACE APPLICATIONS OF NEW MATERIALS
L. ALLGER and J. WHITESIDE 1991 9 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 17: New Materials and Processes)
(CONGRESS PAPER C428-17-135; HTN-95-21147) Copyright

Applications for new materials in Aerospace are governed by the need to increase performance and/or reduce cost over the full product life cycle, together with any specific requirements that are demanded by the operational role. This paper highlights the key structural material development requirements needed to support future military, civil and hypersonic/transatmospheric vehicles and recommends close collaboration between the Material Supply Industry and the Airframe Manufacturing Agencies in pursuance of those goals. Author (Herner)

N95-28823*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THIRD NASA ADVANCED COMPOSITES TECHNOLOGY CONFERENCE, VOLUME 1, PART 2
JOHN G. DAVIS, JR., comp. and HERMAN L. BOHON, comp. (Lockheed Engineering and Sciences Co., Hampton, VA.) Jan. 1993 495 p Conference held in Long Beach, CA, 8-11 Jun. 1992; sponsored by NASA, Washington, and DOD
(Contract(s)/Grant(s): RTOP 510-02-13-01)
(NASA-CP-3178-VOL-1-PT-2; L-17167B-VOL-1-PT-2; NAS 1.55:3178-VOL-1-PT-2) Avail: CASI HC A21/MF A04

This document is a compilation of papers presented at the Third NASA Advanced Composites Technology (ACT) Conference held at Long Beach, California, 8-11 June 1992. The ACT Program is a major multi-year research initiative to achieve a national goal of technology readiness before the end of the decade. Conference papers recorded results of research in the ACT Program in the specific areas of automated fiber placement, resin transfer molding, textile preforms, and stitching as these processes influence design, performance, and cost of composites in aircraft structures. Papers sponsored by the Department of Defense on the Design and Manufacturing of Low Cost Composites (DMLCC) are also included in Volume 2 of this document. For individual titles, see N95-28824 through N95-28849.

N95-28826*# Sundstrand Aviation-Rockford, IL.
IN SITU PROCESSING METHODS FOR COMPOSITE FUSELAGE SANDWICH STRUCTURES
HOSSEIN SAATCHI, BILL DURAKO, DICK REYNOLDS, ERNEST DOST (Boeing Co., Seattle, WA.), and KURTIS WILLDEN (Boeing Co., Seattle, WA.) *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 537-546 Jan. 1993
Avail: CASI HC A02/MF A04

Conventional sandwich structure fabrication methods are labor intensive and high in cost. A low cost method is needed to produce lightweight sandwich structures. Sundstrand has developed a series of in situ composite fabrication methods in which the raw materials (skin and core materials) are placed in a closed mold, and the component is produced in one heating cycle. Internal pressure is generated by chemical agents during the thermal cycles, which consolidates the skins and produces the foam core. The finished part is a net-shape composite sandwich structure with skins and a foamed core. The in situ process reduces cost by eliminating several secondary operations that are used in conventional fabrication methods. Further, a strong molecular bond is produced between the core and skin, which eliminates adhesive bonding and prevents a weak bond section in the sandwich structure. In this investigation, we evaluated the feasibility of the in situ process using thermoset materials currently under consideration for commercial airplane fuselage applications, such as keel sections. The materials used were Hercules 855340 toughened epoxy resin in both liquid and powder forms, and 3M Scotchply PR500 resin, manufactured by 3M Corporation, in powder form. We successfully foamed these resins and produced experimental panels with AS-4/855340 Hercules prepreg skins. Chopped fibers were added to the core to increase performance of the foam. Mechanical property testing on these panels showed properties competitive with other foams. Additional experiments are required to optimize the in situ foam core sandwiches for specific properties and applications. Author

N95-28830*# Grumman Aircraft Engineering Corp., Bethpage, NY.
NOVEL COST CONTROLLED MATERIALS AND PROCESSING FOR PRIMARY STRUCTURES
S. J. DASTIN *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 591-599 Jan. 1993
Avail: CASI HC A02/MF A04

Textile laminates, developed a number of years ago, have recently been shown to be applicable to primary aircraft structures for both small and large components. Such structures have the potential to reduce acquisition costs but require advanced automated processing to keep costs controlled while verifying product reliability and assuring structural integrity, durability and affordable life-cycle costs. Recently, resin systems and graphite-reinforced woven shapes have been developed that have the potential for improved RTM processes for aircraft structures. Ciba-Geigy, Brochier Division has registered an RTM prepreg reinforcement called 'Injectex' that has shown effectivity for aircraft components. Other novel approaches discussed are thermotropic resins producing components by injection molding and ceramic polymers for long-duration hot structures. The potential of such materials and processing will be reviewed along with initial information/data available to date. Author

N95-28832*# Hercules Aerospace Co., Magna, UT. Composite Structures Group.
AUTOMATED FIBER PLACEMENT: EVOLUTION AND CURRENT DEMONSTRATIONS
CARROLL G. GRANT and VERNON M. BENSON *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 625-648 Jan. 1993
Avail: CASI HC A03/MF A04

The automated fiber placement process has been in development at Hercules since 1980. Fiber placement is being developed specifically for aircraft and other high performance structural applications. Several major milestones have been achieved during process development. These milestones are discussed in this paper. The automated fiber placement process is currently being demonstrated on the NASA ACT program. All demonstration projects to date have focused on fiber placement of transport aircraft fuselage structures. Hercules has worked closely with Boeing and Douglas on these demonstration projects. This paper gives a description of demonstration projects and results achieved. Author

N95-28835*# Boeing Commercial Airplane Co., Seattle, WA.
MANUFACTURING SCALE-UP OF COMPOSITE FUSELAGE CROWN PANELS
KURTIS WILLDEN, M. GESSEL, CARROLL G. GRANT (Hercules Aerospace Co., Magna, UT.), and T. BROWN (Hercules Aerospace Co., Magna, UT.) *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 689-704 Jan. 1993
(Contract(s)/Grant(s): NAS1-18889)
Avail: CASI HC A03/MF A04

The goal of the Boeing effort under the NASA ACT program is to reduce manufacturing costs of composite fuselage structure. Materials, fabrication of complex subcomponents and assembly issues are expected to drive the costs of composite fuselage structure. Several manufacturing concepts for the crown section of the fuselage were evaluated through the efforts of a Design Build Team (DBT). A skin-stringer-frame intricate bond design that required no fasteners for the panel assembly was selected for further manufacturing demonstrations. The manufacturing processes selected for the intricate bond design include Advanced Tow Placement (ATP) for multiple skin fabrication, resin transfer molding (RTM) of fuselage frames, innovative cure tooling, and utilization of low-cost material forms. Optimization of these processes for final design/manufacturing configuration was evaluated through the fabrication of several intricate bond panels. Panels up to 7 ft. by 10 ft. in size were fabricated to simulate half scale production parts. The qualitative and quantitative results of these manufacturing demonstrations were used to assess manufacturing risks and technology readiness for production. Author

N95-28836*# Boeing Commercial Airplane Co., Seattle, WA.
DIMENSIONAL STABILITY OF CURVED PANELS WITH COCURED STIFFENERS AND COBONDED FRAMES
G. E. MABSON, B. W. FLYNN, G. D. SWANSON, R. C. LUNDQUIST (Boeing Aerospace Co., Seattle, WA.), and P. L. RUPP (Washington Univ., Seattle, WA.) *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 705-725 Jan. 1993
(Contract(s)/Grant(s): NAS1-18889)
Avail: CASI HC A03/MF A04

Closed form and finite element analyses are presented for axial direction and transverse direction dimensional stability of skin/stringer panels. Several sensitivity studies are presented to illustrate the influence of various design parameters on the dimensional stability of these panels. Panel geometry, material properties (stiffness and coefficient of thermal expansion), restraint conditions and local details, such as resin fillets, all combine to influence dimensional stability, residual and assembly forces. Author

N95-28837*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TENSION FRACTURE OF LAMINATES FOR TRANSPORT FUSELAGE. PART 2: LARGE NOTCHES
TOM H. WALKER (Boeing Commercial Airplane Co., Seattle, WA.), LARRY B. ILCEWICZ (Boeing Commercial Airplane Co., Seattle, WA.), D. R. POLLAND (Boeing Defense and Space Group, Seattle, WA.), and C. C. POE, JR. *In its* Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 727-758 Jan. 1993
(Contract(s)/Grant(s): NAS1-18889)
Avail: CASI HC A03/MF A04

Tests were conducted on over 200 center-crack specimens to evaluate: (a) the tension-fracture performance of candidate materials and laminates for commercial fuselage applications; and (b) the accuracy of several failure criteria in predicting response. Crack lengths of up to 12 inches were considered. Other variables included fiber/matrix combination, layup, lamination manufacturing process, and intraply hybridization. Laminates fabricated using the automated tow-placement process provided significantly higher tension-fracture strengths than nominally identical tape laminates. This confirmed earlier findings for other layups, and possibly relates to a reduced stress concentration resulting from a larger scale of repeatable material inhomogeneity in the tow-placed laminates. Changes in material and layup result in a trade-off between small-notch and large-notch strengths. Toughened resins and 0 deg-dominate layups result in higher small-notch strengths but lower large-notch strengths than brittle resins, 90 deg and 45 deg dominated layups, and intraply S2-glass hybrid material forms. Test results indicate that strength-prediction methods that allow for a reduced order singularity of the crack-tip stress field are more successful at predicting failure over a range of notch sizes than those relying on the classical square-root singularity. The order of singularity required to accurately predict large-notch strength from small-notch data was affected by both material and layup. Measured crack-tip strain distributions were generally higher than those predicted using classical methods. Traditional methods of correcting for finite specimen width were found to be lacking, confirming earlier findings with other specimen geometries. Fracture tests of two stiffened panels, identical except for differing materials, with severed central stiffeners resulted in nearly identical damage progression and failure sequences. Strain-softening laws implemented within finite element models appear attractive to account for load redistribution in configured structure due to damage-induced crack tip softening. Author

N95-28838*# Boeing Co., Seattle, WA.
IMPACT DAMAGE RESISTANCE OF COMPOSITE FUSELAGE STRUCTURE, PART 2
ERNEST F. DOST, SCOTT R. FINN, DANIEL P. MURPHY, and AMY B. HUISKEN *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 759-787 Jan. 1993
(Contract(s)/Grant(s): NAS1-18889)
Avail: CASI HC A03/MF A04

The strength of laminated composite materials may be significantly reduced by foreign object impact induced damage. An understanding of the damage state is required in order to predict the behavior of structure under operational loads or to optimize the structural configuration. Types of damage typically induced in laminated materials during an impact event include transverse matrix cracking, delamination, and/or fiber breakage. The details of the damage state and its influence on structural behavior depend on the location of the impact. Damage in the skin may act as a soft inclusion or affect panel stability, while damage occurring over a stiffener may include debonding of the stiffener flange from the skin. An experiment to characterize impact damage resistance of fuselage structure as a function of structural configuration and impact threat was performed. A wide range of variables associated with aircraft fuselage structure such as material type and stiffener geometry (termed, intrinsic variables) and variables related to the operating environment such as impactor mass and diameter (termed, extrinsic variables) were studied using a statistically based design-of-experiments technique. The experimental design resulted in thirty-two different 3-stiffener panels. These configured panels were impacted in various locations with a number of impactor configurations, weights, and energies. The results obtained from an examination of impacts in the skin midbay and hail simulation impacts are documented. The current discussion is a continuation of that work with a focus on nondiscrete characterization of the midbay hail simulation impacts and discrete characterization of impact damage for impacts over the stiffener. Author

N95-28839*# Boeing Commercial Airplane Co., Seattle, WA.
DESIGN, ANALYSIS, AND FABRICATION OF A PRESSURE BOX TEST FIXTURE FOR TENSION DAMAGE TOLERANCE TESTING OF CURVED FUSELAGE PANELS
P. J. SMITH, J. B. BODINE, C. H. PREUSS, and W. J. KOCH (Boeing Computer Services Co., Seattle, WA.) *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 789-805 Jan. 1993
(Contract(s)/Grant(s): NAS1-18889)
Avail: CASI HC A03/MF A04

A pressure box test fixture was designed and fabricated to evaluate the effects of internal pressure, biaxial tension loads, curvature, and damage on the fracture response of composite fuselage structure. Previous work in composite fuselage tension damage tolerance, performed during NASA contract NAS1-17740, evaluated the above effects on unstiffened panels only. This work extends the tension damage tolerance testing to curved stiffened fuselage crown structure that contains longitudinal stringers and circumferential frame elements. The pressure box fixture was designed to apply internal pressure up to 20 psi, and axial tension loads up to 5000 lb/in, either separately or simultaneously. A NASTRAN finite element model of the pressure box fixture and composite stiffened panel was used to help design the test fixture, and was compared to a finite element model of a full composite stiffened fuselage shell. This was done to ensure that the test panel was loaded in a similar way to a panel in the full fuselage shell, and that the fixture and its attachment plates did not adversely affect the panel. Author

N95-28843*# Northrop Corp., Hawthorne, CA. Aircraft Div.
A WEIGHT-EFFICIENT DESIGN STRATEGY FOR CUTOUTS IN COMPOSITE TRANSPORT STRUCTURES
S. G. RUSSELL, J. HANGEN, and T. E. PALM *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 879-897 Jan. 1993
(Contract(s)/Grant(s): NAS1-18842)
Avail: CASI HC A03/MF A04

Two design procedures for composite panels with cutouts are described and illustrated by example applications. One of these procedures uses a specialized cutout analysis code to obtain preliminary sizing information for the panel laminate, cutout padup, and cutout stiffener reinforcements. The other procedure uses a finite element based structural optimization code to develop a minimum weight panel design. The best features of both procedures form the basis of a design strategy for weight-efficient cutout panels. Author

N95-28845*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
BUCKLING ANALYSIS OF CURVED COMPOSITE SANDWICH PANELS SUBJECTED TO INPLANE LOADINGS
JUAN R. CRUZ *In its* Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 919-932 Jan. 1993
Avail: CASI HC A03/MF A04

Composite sandwich structures are being considered for primary structure in aircraft such as subsonic and high speed civil transports. The response of sandwich structures must be understood and predictable to use such structures effectively. Buckling is one of the most important response mechanisms of sandwich structures. A simple buckling analysis is derived for sandwich structures. This analysis is limited to flat, rectangular sandwich panels loaded by uniaxial compression (N(sub x)) and having simply supported edges. In most aerospace applications, however, the structure's geometry, boundary conditions, and loading are usually very complex. Thus, a general capability for analyzing the buckling behavior of sandwich structures is needed. The present paper describes and evaluates an improved buckling analysis for cylindrically curved composite sandwich panels. This analysis includes orthotropic facesheets and first-order transverse shearing effects. Both simple support and clamped boundary conditions are also included in the analysis. The panels can be subjected to linearly varying normal loads N(sub x) and N(sub y) in addition to a constant shear load N(sub xy). The analysis is based on the modified Donnell's equations for shallow shells. The governing equations are solved by direct application of Galerkin's method. The accuracy of the present analysis is verified by comparing results with those obtained from finite element analysis for a variety of geometries, loads, and boundary conditions. The limitations of the present analysis are investigated, in particular those related to the shallow shell assumptions in the governing equations. Finally, the computational efficiency of the present analysis is considered. Derived from text

N95-28846*# Lockheed Aeronautical Systems Co., Marietta, GA.
ISPAN (INTERACTIVE STIFFENED PANEL ANALYSIS): A TOOL FOR QUICK CONCEPT EVALUATION AND DESIGN TRADE STUDIES
JOHN W. HAIRR, WILLIAM J. DORRIS, J. EDWARD INGRAM, and BHARAT M. SHAH *In* NASA. Langley Research Center, Third

NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 933-949 Jan. 1993
Avail: CASI HC A03/MF A04

Interactive Stiffened Panel Analysis (ISPAN) modules, written in FORTRAN, were developed to provide an easy to use tool for creating finite element models of composite material stiffened panels. The modules allow the user to interactively construct, solve and post-process finite element models of four general types of structural panel configurations using only the panel dimensions and properties as input data. Linear, buckling and post-buckling solution capability is provided. This interactive input allows rapid model generation and solution by non finite element users. The results of a parametric study of a blade stiffened panel are presented to demonstrate the usefulness of the ISPAN modules. Also, a non-linear analysis of a test panel was conducted and the results compared to measured data and previous correlation analysis. Author

N95-28849*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
IPACS (INTEGRATED PROBABILISTIC ASSESSMENT OF COMPOSITE STRUCTURES): CODE DEVELOPMENT AND APPLICATIONS
C. C. CHAMIS and MICHAEL C. SHIAO (Sverdrup Technology, Inc., Brook Park, OH.) *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 987-999 Jan. 1993
Avail: CASI HC A03/MF A04

A methodology and attendant computer code have been developed and are described to computationally simulate the uncertain behavior of composite structures. The uncertain behavior includes buckling loads, stress concentration factors, displacements, stress/strain etc., which are the consequences of the inherent uncertainties (scatter) in the primitive (independent random) variables (constituent, ply, laminate and structural) that describe the composite structures. The computer code, IPACS (Integrated Probabilistic Assessment of Composite Structures), can handle both composite mechanics and composite structures. Application to probabilistic composite mechanics is illustrated by its uses to evaluate the uncertainties in the major Poisson's ratio and in laminate stiffness and strength. IPACS application to probabilistic structural analysis is illustrated by its use to evaluate the uncertainties in the buckling of a composite plate, in the stress concentration factor in a composite panel and in the vertical displacement and ply stress in a composite aircraft wing segment. Author

N95-29029*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THIRD NASA ADVANCED COMPOSITES TECHNOLOGY CONFERENCE, VOLUME 1, PART 1
JOHN G. DAVIS, JR., comp. and HERMAN L. BOHON, comp. (Lockheed Engineering and Sciences Co., Hampton, VA.) Jan. 1993 498 p Conference held in Long Beach, CA, 8-11 Jun. 1992; sponsored by NASA, Washington and DOD
(Contract(s)/Grant(s): RTOP 510-02-13-01)
(NASA-CP-3178-VOL-1-PT-1; L-17167A-VOL-1-PT-1; NAS 1.55:3178-VOL-1-PT-1) Avail: CASI HC A21/MF A04

This document is a compilation of papers presented at the Third NASA Advanced Composites Technology (ACT) Conference. The ACT Program is a major multi-year research initiative to achieve a national goal of technology readiness before the end of the decade. Conference papers recorded results of research in the ACT Program in the specific areas of automated fiber placement, resin transfer molding, textile preforms, and stitching as these processes influence design, performance, and cost of composites in aircraft structures. Papers sponsored by the Department of Defense on the Design and Manufacturing of Low Cost Composites (DMLCC) are also included in Volume 2 of this document. For individual titles, see N95-29030 through N95-29051.

N95-29030*# Douglas Aircraft Co., Inc., Long Beach, CA.
IMPACT OF COMPOSITES ON FUTURE TRANSPORT AIRCRAFT
ROBERT H. KINDER *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 3-24 Jan. 1993
Avail: CASI HC A03/MF A04

In the current environment, new technology must be cost-effective in addition to improving operability. Various approaches have been used to determine the 'hurdle' or 'breakthrough' return that must be achieved to gain customer commitment for a new product or aircraft, or in this case, a new application of the technology. These approaches include return-on-investment, payback period, and addition to net worth. An easily understood figure-of-merit and one used by our airline customers is improvement in direct operating cost per seat-mile. Any new technology must buy its way onto the aircraft through reduction in direct operating cost (DOC). Derived from text

N95-29031*# Boeing Co., Seattle, WA.
CHALLENGES AND PAYOFF OF COMPOSITES IN TRANSPORT AIRCRAFT: 777 EMPENNAGE AND FUTURE APPLICATIONS
JOHN QUINLIVAN *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 25-45 Jan. 1993
Avail: CASI HC A03/MF A04

The Boeing 777 is the first of a new family of wide body airplanes. The new large twin is sized to accommodate 360 to 390 passengers in typical two-class configurations and planned growth beyond that. The 777 offers airlines three engine options, extremely attractive operating costs, and compatibility with existing airport gates and taxiways. The 777 has a wingspan of nearly 197 feet and is offered with a wing-tip folding mechanism that will reduce the span to 156 feet. Extensive use of advance composite is included in the 777. The application range from fiberglass fairing to primary structures. The 777 empennage includes vertical fin and a horizontal stabilizer. The material used for the empennage is a new, toughened epoxy materials. The material provides outstanding resistance to impact damage. Derived from text

N95-29032*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ADVANCED COMPOSITES TECHNOLOGY PROGRAM
JOHN G. DAVIS, JR. *In its* Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 49-78 Jan. 1993
Avail: CASI HC A03/MF A04

This paper provides a brief overview of the NASA Advanced Composites Technology (ACT) Program. Critical technology issues that must be addressed and solved to develop composite primary structures for transport aircraft are delineated. The program schedule and milestones are included. Work completed in the first 3 years of the program indicates the potential for achieving composite structures that weigh less and are cost effective relative to conventional aluminum structure. Selected technical accomplishments are noted. Readers who are seeking more in-depth technical information should study the other papers included in these proceedings. Derived from text

N95-29033*# Lockheed Aeronautical Systems Co., Marietta, GA.
TEXTILE COMPOSITE FUSELAGE STRUCTURES DEVELOPMENT
ANTHONY C. JACKSON, RONALD E. BARRIE, and ROBERT L. CHU *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 79-96 Jan. 1993
(Contract(s)/Grant(s): NAS1-18888)
Avail: CASI HC A03/MF A04

Phase 2 of the NASA ACT Contract (NAS1-18888), Advanced Composite Structural Concepts and Materials Technology for Transport Aircraft Structures, focuses on textile technology, with resin transfer molding or powder coated tows. The use of textiles has the potential for improving damage tolerance, reducing cost and saving

weight. This program investigates resin transfer molding (RTM), as a maturing technology for high fiber volume primary structures and powder coated tows as an emerging technology with a high potential for significant cost savings and superior structural properties. Powder coated tow technology has promise for significantly improving the processibility of high temperature resins such as polyimides.
Derived from text

N95-29034*# Boeing Commercial Airplane Co., Seattle, WA.
ADVANCED COMPOSITE FUSELAGE TECHNOLOGY
LARRY B. ILCEWICZ, PETER J. SMITH, and RAY E. HORTON *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 97-156 Jan. 1993
(Contract(s)/Grant(s): NAS1-18889)
Avail: CASI HC A04/MF A04

Boeing's ATCAS program has completed its third year and continues to progress towards a goal to demonstrate composite fuselage technology with cost and weight advantages over aluminum. Work on this program is performed by an integrated team that includes several groups within The Boeing Company, industrial and university subcontractors, and technical support from NASA. During the course of the program, the ATCAS team has continued to perform a critical review of composite developments by recognizing advances in metal fuselage technology. Despite recent material, structural design, and manufacturing advancements for metals, polymeric matrix composite designs studied in ATCAS still project significant cost and weight advantages for future applications. A critical path to demonstrating technology readiness for composite transport fuselage structures was created to summarize ATCAS tasks for Phases A, B, and C. This includes a global schedule and list of technical issues which will be addressed throughout the course of studies. Work performed in ATCAS since the last ACT conference is also summarized. Most activities relate to crown quadrant manufacturing scaleup and performance verification. The former was highlighted by fabricating a curved, 7 ft. by 10 ft. panel, with cocured hat-stiffeners and cobonded J-frames. In building to this scale, process developments were achieved for tow-placed skins, drape formed stiffeners, braided/RTM frames, and panel cure tooling. Over 700 tests and supporting analyses have been performed for crown material and design evaluation, including structural tests that demonstrated limit load requirements for severed stiffener/skin failsafe damage conditions. Analysis of tests for tow-placed hybrid laminates with large damage indicates a tensile fracture toughness that is higher than that observed for advanced aluminum alloys. Additional recent ATCAS achievements include crown supporting technology, keel quadrant design evaluation, and sandwich process development. Author

N95-29035*# Lockheed Aeronautical Systems Co., Marietta, GA.
ADVANCED RESIN SYSTEMS AND 3D TEXTILE PREFORMS FOR LOW COST COMPOSITE STRUCTURES
J. G. SHUKLA and T. D. BAYHA *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 159-173 Jan. 1993
Avail: CASI HC A03/MF A04

Advanced resin systems and 3D textile preforms are being evaluated at Lockheed Aeronautical Systems Company (LASC) under NASA's Advanced Composites Technology (ACT) Program. This work is aimed towards the development of low-cost, damage-tolerant composite fuselage structures. Resin systems for resin transfer molding and powder epoxy towpreg materials are being evaluated for processability, performance and cost. Three developmental epoxy resin systems for resin transfer molding (RTM) and three resin systems for powder towpregging are being investigated. Various 3D textile preform architectures using advanced weaving and braiding processes are also being evaluated. Trials are being conducted with powdered towpreg, in 2D weaving and 3D braiding processes for their textile processability and their potential for fabrication in 'net shape' fuselage structures. The progress in advanced resin screening and textile preform development is reviewed here. Author

N95-29036*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WEAVABILITY OF DRY POLYMER POWDER TOWPREG
MAYLENE K. HUGH (Old Dominion Univ., Norfolk, VA.), JOSEPH M. MARCHELLO (Old Dominion Univ., Norfolk, VA.), JANICE R. MAIDEN (Textile Technologies, Inc., Hatboro, PA.), and NORMAN J. JOHNSTON *In its* Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 175-189 Jan. 1993
(Contract(s)/Grant(s): NAG1-1067)
Avail: CASI HC A03/MF A04

Carbon fiber yarns (3k, 6k, 12k) were impregnated with LARC (tm) thermoplastic polyimide dry powder. Parameters for weaving these yarns were established. Eight-harness satin fabrics were successfully woven from each of the three classes of yarns and consolidated into test specimens to determine mechanical properties. It was observed that for optimum results warp yarns should have flexural rigidities between 10,000 and 100,000 mg-cm. Tow handling minimization, low tensioning, and tow bundle twisting were used to reduce fiber breakage, the separation of filaments, and tow-to-tow abrasion. No apparent effect of tow size or twist was observed on either tension or compression modulus. However, fiber damage and processing costs favor the use of 12k yarn bundles versus 3k or 6k yarn bundles in the weaving of powder-coated towpreg. Author

N95-29038*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MECHANICAL CHARACTERIZATION OF 2D, 2D STITCHED, AND 3D BRAIDED/RTM MATERIALS
JERRY W. DEATON, SUSAN M. KULLERD (Lockheed Engineering and Sciences Co., Hampton, VA.), and MARC A. PORTANOVA (Lockheed Engineering and Sciences Co., Hampton, VA.) *In its* Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 209-230 Jan. 1993
Avail: CASI HC A03/MF A04

Braided composite materials have potential for application in aircraft structures. Fuselage frames, floor beams, wing spars, and stiffeners are examples where braided composites could find application if cost effective processing and damage tolerance requirements are met. Another important consideration for braided composites relates to their mechanical properties and how they compare to the properties of composites produced by other textile composite processes being proposed for these applications. Unfortunately, mechanical property data for braided composites do not appear extensively in the literature. Data are presented in this paper on the mechanical characterization of 2D triaxial braid, 2D triaxial braid plus stitching, and 3D (through-the-thickness) braid composite materials. The braided preforms all had the same graphite tow size and the same nominal braid architectures, (+/- 30 deg/0 deg), and were resin transfer molded (RTM) using the same mold for each of two different resin systems. Static data are presented for notched and unnotched tension, notched and unnotched compression, and compression after impact strengths at room temperature. In addition, some static results, after environmental conditioning, are included. Baseline tension and compression fatigue results are also presented, but only for the 3D braided composite material with one of the resin systems. Derived from text

N95-29039*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PERFORMANCE OF RESIN TRANSFER MOLDED MULTIAXIAL WARP KNIT COMPOSITES
H. BENSON DEXTER and GREGORY H. HASKO (Lockheed Engineering and Sciences Co., Hampton, VA.) *In its* Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 231-261 Jan. 1993
Avail: CASI HC A03/MF A04

Composite materials that are subjected to complex loads have traditionally been fabricated with multidirectionally oriented prepreg tape materials. Some of the problems associated with this type of

construction include low delamination resistance, poor out-of-plane strength, and labor intensive fabrication processes. Textile reinforced composites with through-the-thickness reinforcement have the potential to solve some of these problems. Recently, a relatively new class of noncrimp fabrics designated as multiaxial warp knits have been developed to minimize some of the high cost and damage tolerance concerns. Multiple stacks of warp knit fabrics can be knitted or stitched together to reduce layup labor cost. The through-the-thickness reinforcement can provide significant improvements in damage tolerance and out-of-plane strength. Multilayer knitted/stitched preforms, in conjunction with resin transfer molding (RTM), offer potential for significant cost savings in fabrication of primary aircraft structures. The objectives of this investigation were to conduct RTM processing studies and to characterize the mechanical behavior of composites reinforced with three multiaxial warp knit fabrics. The three fabrics investigated were produced by Hexcel and Milliken in the United States, and Saerbeck in Germany. Two resin systems, British Petroleum E905L and 3M PR 500, were characterized for RTM processing. The performance of Hexcel and Milliken quasi-isotropic knitted fabrics are compared to conventional prepreg tape laminates. The performance of the Saerbeck fabric is compared to uniweave wing skin layups being investigated by Douglas Aircraft Company in the NASA Advanced Composites Technology (ACT) program. Tests conducted include tension, open hole tension, compression, open hole compression, and compression after impact. The effects of fabric defects, such as misaligned fibers and gaps between tows, on material performance are also discussed. Estimated material and labor cost savings are projected for the Saerbeck fabric as compared to uniweave fabric currently being used by Douglas in the NASA ACT wing development program.
Derived from text

N95-29041*# Grumman Aircraft Engineering Corp., Bethpage, NY.
CROSS-STIFFENED CONTINUOUS FIBER STRUCTURES
JOHN R. EWEN and JIM A. SUAREZ *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 287-308 Jan. 1993
Avail: CASI HC A03/MF A04

Under NASA's Novel Composites for Wing and Fuselage Applications (NCWFA) program, Contract NAS1-18784, Grumman is evaluating the structural efficiency of graphite/epoxy cross-stiffened panel elements fabricated using innovative textile preforms and cost effective Resin Transfer Molding (RTM) and Resin Film Infusion (RFI) processes. Two three-dimensional woven preform assembly concepts have been defined for application to a representative window belt design typically found in a commercial transport airframe. The 3D woven architecture for each of these concepts is different; one is vertically woven in the plane of the window belt geometry and the other is loom woven in a compressed state similar to an unfolded eggcrate. The feasibility of both designs has been demonstrated in the fabrication of small test element assemblies. These elements and the final window belt assemblies will be structurally tested, and results compared. Author

N95-29043*# Boeing Commercial Airplane Co., Seattle, WA.
COST MODEL RELATIONSHIPS BETWEEN TEXTILE MANUFACTURING PROCESSES AND DESIGN DETAILS FOR TRANSPORT FUSELAGE ELEMENTS
STEPHEN L. METSCHAN, KURTIS S. WILDEN, GARRETT C. SHARPLESS (Fiber Innovations, Inc., Norwood, MA.), and RICH M. ANDELMAN (Dow Chemical Co., Midland, MI.) *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 323-340 Jan. 1993
(Contract(s)/Grant(s): NAS1-18889)
Avail: CASI HC A03/MF A04

Textile manufacturing processes offer potential cost and weight advantages over traditional composite materials and processes for transport fuselage elements. In the current study, design cost modeling relationships between textile processes and element design details were developed. Such relationships are expected to help future aircraft designers to make timely decisions on the effect of design details and overall configurations on textile fabrication costs. The fundamental advantage of a design cost model is to insure that the element design is cost effective for the intended process. Trade studies on the effects of processing parameters also help to optimize the manufacturing steps for a particular structural element. Two methods of analyzing design detail/process cost relationships developed for the design cost model were pursued in the current study. The first makes use of existing databases and alternative cost modeling methods (e.g. detailed estimating). The second compares design cost model predictions with data collected during the fabrication of seven foot circumferential frames for ATCAS crown test panels. The process used in this case involves 2D dry braiding and resin transfer molding of curved 'J' cross section frame members having design details characteristic of the baseline ATCAS crown design. Author

N95-29044*# Dow Chemical Co., Midland, MI.
DEVELOPMENT OF RTM AND POWDER PREPREG RESINS FOR SUBSONIC AIRCRAFT PRIMARY STRUCTURES
EDMUND P. WOO, MICHAEL R. GROLEAU, JAMES L. BERTRAM (Dow Chemical Co., Freeport, TX.), PAUL M. PUCKETT (Dow Chemical Co., Freeport, TX.), and SHAWN J. MAYNARD (Dow Chemical Co., Freeport, TX.) *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 345-360 Jan. 1993
(Contract(s)/Grant(s): NAS1-18841)
Avail: CASI HC A03/MF A04

Dow developed a thermoset resin which could be used to produce composites via the RTM process. The composites formed are useful at 200 F service temperatures after moisture saturation, and are tough systems that are suitable for subsonic aircraft primary structure. At NASA's request, Dow also developed a modified version of the RTM resin system which was suitable for use in producing powder prepreg. In the course of developing the RTM and powder versions of these resins, over 50 different new materials were produced and evaluated. Author

N95-29047*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE EFFECTS OF AIRCRAFT FUEL AND FLUIDS ON THE STRENGTH PROPERTIES OF RESIN TRANSFER MOLDED (RTM) COMPOSITES
ANTHONY FALCONE (Boeing Defense and Space Group, Seattle, WA.) and MARVIN B. DOW *In its* Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 399-413 Jan. 1993
(Contract(s)/Grant(s): NAS1-18954)
Avail: CASI HC A03/MF A04

The resin transfer molding (RTM) process offers important advantages for cost-effective composites manufacturing, and consequently has become the subject of intense research and development efforts. Several new matrix resins have been formulated specifically for RTM applications in aircraft and aerospace vehicles. For successful use on aircraft, composite materials must withstand exposure to the fluids in common use. The present study was conducted to obtain comparative screening data on several stateofthe-art RTM resins after environmental exposures were performed on RTM composite specimens. Four graphite/epoxy composites and one graphite/bismaleimide composite were tested; testing of two additional graphite epoxy composites is in progress. Zero-deg tension tests were conducted on specimens machined from eight-ply (+45-deg, -45-deg) laminates, and interlaminar shear tests were conducted on 32-ply 0-deg laminate specimens. In these tests, the various RTM resins demonstrated widely different strengths, with 3501-6 epoxy being the strongest. As expected, all of the matrix resins suffered severe strength degradation from exposure to methylene chloride (paint stripper). The 3501-6 epoxy composites exhibited about a 30 percent drop in tensile strength in hot, wet tests. The E905-L epoxy exhibited little loss of tensile strength (less than 8 percent) after exposure to water. The CET-2 and 862 epoxies as well as the bismaleimide exhibited reduced strengths at elevated temperature after exposure to oils and fuel. In terms of the percentage strength reductions, all of the RTM matrix resins compared favorably with 3501-6 epoxy. Author

N95-29050*# Douglas Aircraft Co., Inc., Long Beach, CA.
PROGRESS IN MANUFACTURING LARGE PRIMARY AIRCRAFT STRUCTURES USING THE STITCHING/RTM PROCESS
ALAN MARKUS, PATRICK THRASH, and KIM ROHWER *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 453-479 Jan. 1993
Avail: CASI HC A03/MF A04

The Douglas Aircraft/NASA Act contract has been focused over the past three years at developing a materials, manufacturing, and cost base for stitched/Resin Transfer Molded (RTM) composites. The goal of the program is to develop RTM and stitching technology to provide enabling technology for application of these materials in primary aircraft structure with a high degree of confidence. Presented in this paper will be the progress to date in the area of manufacturing and associated cost values of stitched/RTM composites. Derived from text

N95-29051*# Douglas Aircraft Co., Inc., Long Beach, CA.
TEST RESULTS FROM LARGE WING AND FUSELAGE PANELS
RAM C. MADAN and MIKE VOLDMAN *In* NASA. Langley Research Center, Third NASA Advanced Composites Technology Conference, Volume 1, Part 1 p 481-502 Jan. 1993
Avail: CASI HC A03/MF A04

This paper presents the first results in an assessment of the strength, stiffness, and damage tolerance of stiffened wing and fuselage subcomponents. Under this NASA funded program, 10 large wing and fuselage panels, variously fabricated by automated tow placement and dry-stitched preform/resin transfer molding, are to be tested. The first test of an automated tow placement six-longeron fuselage panel under shear load was completed successfully. Using NASTRAN finite-element analysis the stiffness of the panel in the linear range prior to buckling was predicted within 3.5 percent. A nonlinear analysis predicted the buckling load within 10 percent and final failure load within 6 percent. The first test of a resin transfer molding six-stringer wing panel under compression was also completed. The panel failed unexpectedly in buckling because of inadequate supporting structure. The average strain was 0.43 percent with a line load of 20.3 kips per inch of width. This strain still exceeds the design allowable strains. Also, the stringers did not debond before failure, which is in contrast to the general behavior of unstitched panels. Author

N95-29482 Lockheed Aeronautical Systems Co., Marietta, GA.
THERMALLY STABLE ORGANIC POLYMERS Final Report, 1 Feb. 1993 - 30 Jun. 1994
R. S. BOSCHAN, MATTHEW MARROCCO, and JAMES MCGRATH 30 Jun. 1994 21 p Prepared in cooperation with Maxdem, Inc., and Virginia Polytechnic Institute and State Univ Limited Reproducibility: More than 20% of this document may be affected by poor print
(Contract(s)/Grant(s): DAAL03-92-C-0021)
(AD-A290755; LG94ER0129; ARO-30357.2-MS) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

Environmentally durable high temperature polymer matrix resins are critical in the design of near-term high performance supersonic aircraft. Currently available 6F based polymers are thermally stable, but are expensive and difficulty processable into void-free laminates. 3F polymers have demonstrated equivalent thermal stability and processability, but are amenable to more facile, environmentally acceptable synthetic procedures. In the current program, Semi-interpenetrating Polymer Network (SIPN) blends of ethynyl and phenylethynyl terminated 3F polymers have been formulated, synthesized, and scaled up to quantities amenable to prepregging. Solution prepregging techniques were used by YLA, Inc. to fabricate 12 inch unidirectional prepreg tape. A series of test panels was fabricated from the IM7 prepreg tape, using dielectric monitoring procedures, from a 1:1 3F SIPN blend of phthalic anhydride terminated thermoplastic 3F oligomer with a phenylethynyl terminated 3F oligomer. Solution prepregging techniques were used to prepare unidirectional IM7 fiber prepreg tape. The primary goals of the program, including conception, synthesis development, scaleup, prepregging and panel fabrication, were all met. The void content of the laminates was somewhat higher than acceptable, probably due to the high melt viscosity and solvent inclusion. A plan, using powder prepregging, was offered to alleviate the void problem. DTIC

N95-29572# Army Tank-Automotive Systems Development Center, Warren, MI.
EVALUATION OF COMMERCIAL WATER-IN-FUEL TEST KITS Final Report
WILLIAM R. WILLIAMS and CHRIS KEEHAN Dec. 1994 25 p
(AD-A292135; TARDEC-TR-13613) Avail: CASI HC A03/MF A01

This report describes evaluation tests on four commercial water-in-fuel test kits intended to measure the level of free water in aircraft fuels. Evaluations were conducted using water saturated fuel deliberately contaminated with predetermined levels of free water. The readings of the test kits were compared to determine the test kit that is most appropriate for Army use. DTIC

N95-29842# Florida Univ., Gainesville, FL. Dept. of Materials Science and Engineering.
INNOVATIVE PROCESSING OF COMPOSITES FOR ULTRA-HIGH TEMPERATURE APPLICATIONS, BOOK 1 Final Report
REZA ABBASCHIAN Sep. 1994 78 p
(Contract(s)/Grant(s): N00014-91-J-4075)
(AD-A290889) Avail: CASI HC A05/MF A01

Processing and Properties of Silicon Carbide Fibers; Processing of Mullite Composite Fibers; Chemical Vapor Deposition (CVD) and Chemical Vapor Infiltration (CVI) are described is this report. DTIC

N95-30252*# IMITECH, Inc., Schenectady, NY.
DEVELOPMENT OF LARC (TM): IA THERMOPLASTIC POLYIMIDE COATED AEROSPACE WIRING
JACK KEATING Mar. 1995 55 p
(Contract(s)/Grant(s): NAS1-20121; RTOP 506-43-11-01)
(NASA-CR-195048; NAS 1.26:195048) Avail: CASI HC A04/MF A01

NASA Langley has invented LaRC(exp TM) IA and IAX which are thermoplastic polyimides with good melting, thermal and chemical resistance properties. It was the objective of this contract to prepare and extrude LaRC (exp TM) polyimide onto aircraft wire and evaluate the polymers performance in this critical application. Based on rheology and chemical resistance studies at Imitec, LaRC (exp TM) IAX melts readily in an extruder, facilitating the manufacture of thin wall coatings. The polyimide does not corode the extruder, develop gel particles nor advance in viscosity. The insulated wire was tested according to MiL-W-22759E test specifications. The resulting wire coated with LaRC (exp TM) IAX displayed exceptional properties: surface resistance, non blocking, non burning, hot fluid resistance, impulse dielectric, insulation resistance, low temperature flexibility, thermal aging, wire weight, dimensions, negligible high temperature shrinkage and stripability. The light weight and other properties merit its application in satellites, missiles and aircraft applications. The extruded IAX results in a polyimide aircraft insulation without seams, outstanding moisture resistance, continuous lengths and abrasion resistance. Author

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ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A95-86857
DRAG COEFFICIENTS OF SPHERICAL LIQUID DROPLETS. PART 1: QUIESCENT GASEOUS FIELDS
W. D. WARNICA BHP Research, Wallsend, Australia, M. RENKSIZBULUT, and A. B. STRONG Experiments in Fluids (ISSN 0723-4864) vol. 18, no. 4 February 1995 p. 258-264 (BTN-95-EIX95262697040) Copyright

The drag coefficient of non-evaporating, spherical, liquid droplets in quiescent gaseous fields is measured using a novel experimental methodology at Reynolds numbers from 20 to 120. The experimental uncertainties are typically less than 8 percent, and the results are on average within 6 percent of the drag coefficient of liquid and rigid spheres, based on an accepted relationship. The methodology described in this article is therefore validated so it can be extended with confidence to measurements in turbulent gaseous fields. Author (EI)

A95-86858
DRAG COEFFICIENTS OF SPHERICAL LIQUID DROPLETS. PART 2: TURBULENT GASEOUS FIELDS
W. D. WARNICA BHP Research, Wallsend, Australia, M. RENKSIZBULUT, and A. B. STRONG Experiments in Fluids (ISSN 0723-4864) vol. 18, no. 4 February 1995 p. 265-275 (BTN-95-EIX95262697041) Copyright

The drag of non-evaporating, spherical, liquid droplets was measured in turbulent flow fields at parametric ranges relevant to spray combustion, characterized by the droplet Reynolds number, and the intensity and spatial scales of turbulence. Spatial scales of turbulence were large in comparison to the droplets: the ratio between the spatial integral scale and the droplet diameter was in the range 11-38, and the Kolmogorov scale was comparable in size or smaller than the droplet diameter. Experimental data showed that the drag in turbulent fields under these conditions is not significantly different than that of solid spheres in a quiescent field at the same Reynolds number. EI

A95-86893
MESH GENERATION AND ADAPTIVITY FOR THE SOLUTION OF COMPRESSIBLE VISCOUS HIGH SPEED FLOWS
O. HASSAN Univ of Wales, Swansea, United Kingdom, E. J. PROBERT, K. MORGAN, and J. PERAIRE International Journal for Numerical Methods in Engineering (ISSN 0029-5981) vol. 38, no. 7 April 15 1995 p. 1123-1148 refs (BTN-95-EIX95262697157) Copyright

An implicit-explicit procedure for the solution of the compressible Navier-Stokes equations on unstructured triangular and tetrahedral meshes is outlined. A procedure for constructing continuous lines, made up of edges in the mesh, is employed and the implicit equation system is solved via line relaxation. The problem of generating, and adapting, unstructured meshes for viscous flow simulations is addressed. A number of examples are included which demonstrate the numerical performance of the proposed procedures. Author (EI)

A95-87184
PULSED JET IGNITION MODELING WITH A FULL CHEMISTRY
A. K. HAYASHI Nagoya University, Nagoya, Japan and M. HISHIDA Nagoya University, Nagoya, Japan *In* Turbulence and molecular processes in combustion; Toyota Conference, 6th, Shizuoka, Japan, Oct. 11-14, 1992. A95-87170 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1993 p. 199-220 Copyright

Phenomena on ignition and combustion of a pulsed jet in a reactive atmosphere are simulated by three-dimensional Reynolds averaged full Navier-Stokes equations with a full H2/Air chemical kinetic mechanism to analyze an unsteady combustible turbulent flow. A full hydrogen-air reaction mechanism is used to evaluate the effect of vortices on the flame propagation accurately. The mechanism consists of nine species including H2, O2, H2O, H2O2, HO2, OH, H, and O as reactive species and N2 as non-reactive one, and nineteen elementary reactions. The second-order point implicit Harten-Yee non-Monotone Upstream-centered Schemes for Conservation Laws (MUSCL) modified-flux type Total Variation Diminishing (TVD) scheme and the second-order central difference scheme are used to difference the convective and viscous terms respectively. The averaged state at the mid grid points is given to evaluate the numerical dissipation by the Roe's averaged state. The numerical simulation shows that the flame is distorted by the compression waves (weak shock waves) due to the baroclinic effects as well as vortex shears under the weak compressibility conditions. The OH radical production and consumption are also influenced by the dynamics of vortices. Author (Hemer)

A95-87191
INTRINSIC TRANSPORT AND CHEMISTRY COUPLING IN COMBUSTION PHENOMENA
C. K. LAW Princeton University, Princeton, NJ, US, F. N. EGOLFOPOULOS University of Southern California, Los Angeles, CA, US, and T. G. KREUTZ Princeton University, Princeton, NJ, US *In* Turbulence and molecular processes in combustion; Toyota Conference, 6th, Shizuoka, Japan, Oct. 11-14, 1992. A95-87170 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1993 p. 311-326 Research sponsored by the Army Research Office, the Air Force Office of Scientific Research, and the Department of Energy
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Unified descriptions are obtained for the coupled influence of transport and complex chemistry on the phenomena of fundamental flammability limits and of the counterflow ignition of a cold hydrogen jet by a hot air jet. Results on flammability show that, at a characteristics loss-induced extinction turning point, the dominant chain branching reaction simultaneously becomes exponentially less significant to the flame response than does the dominant termination reaction. Consideration of kinetic termination further explains several experimentally observed flammability phenomena. Results on counterflow hydrogen jet ingition show that the ignition response of this diffusive system can be closely related to the explosion limits of homogeneous H2/air mixtures by considering radical generation and destruction within a spatially-localized ignition 'kernel', and the loss of these radicals from the ignition kernel due to transport processes. Author (Hemer)

A95-87195
PREDICTION OF NO(X) EMISSION INDEX OF TURBULENT DIFFUSION FLAME
TADAO TAKENO Nagoya University, Nagoya, Japan, MAKIHITO NISHIOKA Nagoya University, Nagoya, Japan, and HIROSHI YAMASHITA Nagoya University, Nagoya, Japan *In* Turbulence and molecular processes in combustion; Toyota Conference, 6th, Shizuoka, Japan, Oct. 11-14, 1992. A95-87170 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1993 p. 375-391
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A new method to predict NO(x) emission index of turbulent diffusion flame is proposed. In the laminar flamelet regime, the main reactions are concentrated in the rather narrow, strip-like high temperature region. NO(x) is produced only in this region, where the most fuel is consumed simultaneously. Then at any local position of this fluctuating strip-like region, we can define the instantaneous local emission index by dividing the NO(x) production rate by the fuel consumption rate, per unit surface area of the strip, at that instant. The proposed method is based on this basic idea. The local index is calculated for the steady laminar counterflow diffusion flame by adopting the detailed kinetics of the large mechanism, as a function of the scalar dissipation rate at the apparent flame surface position. The latter represents the inverse of a characteristic diffusion time in the reaction zone. On the other hand, the large scale coherent structure of the turbulent diffusion flame is studied numerically by adopting the flame surface model of infinite reaction rate, and by solving directly the time dependent Navier-Stokes equation by using a finite difference method. Then the instantaneous scalar dissipation rate at any local flame surface position is calculated to yield the probability density function of this quantity in the turbulent diffusion flame. The emission index of the whole flame is obtained by taking an average of the local indices in terms of the probability density function. In this way, the combination of these two types calculation makes it possible to predict the emission index of the turbulent diffusion flame. The paper will describe some preliminary results of the attempt, and their comparison with existing experimental data. Author (Herner)

A95-87220
VORTICITY IN AN INVISCID FLUID AT HYPERSONIC SPEEDS
DAVID NIXON The Queen's University of Belfast, Belfast, UK
AIAA Journal (ISSN 0001-1452) vol. 32, no. 12 December 1994 p. 2474-2475
(Contract(s)/Grant(s): F49620-91-C-0037)
(HTN-95-42590) Copyright

This Note describes a simple analysis of vorticity evaluation at high Mach numbers. Since vorticity is the cornerstone of classical turbulence theories, it is helpful to establish whether these theories can be valid at very high Mach numbers. Since analysis of turbulence itself is almost impossible, a simple model problem is posed, namely, the steady flow of an inviscid fluid with constant total enthalpy but with an arbitrary prescribed initial vorticity. It is assumed that the fluid can be accelerated isentropically to a very high Mach number where it becomes steady. Although inviscid, the model problem does relate to turbulence, since large-scale turbulence is more or less independent of viscosity. Author (Herner)

A95-87280
A FLOW PATTERN MAP FOR TWO-PHASE LIQUID-GAS FLOW UNDER REDUCED GRAVITY CONDITIONS
K. S. REZKALLAH Univ. of Saskatchewan, Saskatoon, Saskatchewan, Canada and L. ZHAO Univ. of Saskatchewan, Saskatoon, Saskatchewan, Canada Microgravity sciences: Results and analysis of recent spaceflights; Symposium G1 of COSPAR Scientific Assembly, 30th, Hamburg, Germany, July 11-21, 1994. A95-87258 Advances in Space Research (ISSN 0273-1177) vol. 16, no. 7 1995 p. (7)133-(7)136
Copyright

Two-phase gas-liquid flows have a wide range of applications in space including the flow of cryogenics in transport lines and heat-transfer fluids in a thermal control system. The behavior of these systems under reduced gravity must be understood in order to optimize the design and maintenance of such systems. Experimental studies on two-phase flow patterns and their transitions were conducted aboard the NASA KC-135 aircraft. A large set of flow pattern data for water-air and glycerin/water-air of different viscosities was reported. It was shown that two-phase flow under reduced gravity can be classified into four glow patterns: bubbly, slug, frothy slug-annular, and annular flows. Transitions between slug and frothy slug-annular, and frothy slug-annular and annular flows were predicted well using the liquid and gas Weber numbers as the mapping coordinates. Author (Herner)

A95-87330
A NEW PARADIGM: THE INVESTMENT CASTING COOPERATIVE ARRANGEMENT
BOYD A. MUELLER Opherall Research Center, Whitehall, MI, US and PHILIP MONAGHAN Opherall Research Center, Whitehall, MI, US JOS (ISSN 1047-4838) vol. 46, no. 9 September 1994 p. 17-20 Research sponsored by ARPA
(HTN-95-92510) Copyright

Under the leadership of five collaborating companies, the Investment Casting Cooperative Arrangement (ICCA) is in the first two years of a six-year vision that will contribute to maintaining the U.S. competitive advantage in aerospace and, more specifically, aeropropulsion. Equally important is the new paradigm that is being developed for other technologies and industries; it includes the ability of competitive companies to work together as a team in the development of generic technologies that will enhance overall competitiveness. A critical component in the success of a program such as the ICCA is the team's ability to network and interact with other consortia operating with the same technologies so that the efforts are aligned, all resources are being leveraged, and frequent lines of communication have been established at all levels. As a result, the ICCA provides a model framework for genuine interaction among industry, federal laboratories, and universities. Author (Herner)

A95-87530
RAPID PROTOTYPING OF COMPOSITE AIRCRAFT STRUCTURES
GEORGE BENNETT Mississippi State Univ., MS State, MS, US, MASOUD RAIS-ROHANI Mississippi State Univ., MS State, MS, US, KENNETH HALL Mississippi State Univ., MS State, MS, US, WALT HOLIFIELD Mississippi State Univ., MS State, MS, US, RANI SULLIVAN Mississippi State Univ., MS State, MS, US, and SCOTT BROWN Mississippi State Univ., MS State, MS, US (ISSN 0148-7191) 1993 18 p. SAE General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, KS, May 18-20, 1993
(SAE PAPER 931219; HTN-95-51892) Copyright

The faculty, staff and students of the Raspet Flight Research Laboratory (RFRL) have developed a rapid prototyping capability in a series of research aircraft and unmanned aircraft development projects. There has been a steady change in the technologies used to accomplish these tasks at the RFRL. The most recent development has been the utilization of computer graphics and a 5-axis gantry robot router to accelerate the design, moldmaking and parts trimming tasks. The composite structure fabrication processes at the RFRL have evolved from wet-lay-up to autoclave curve. Currently, the feasibility of the stitched composite material preform and resin transfer molding process is being explored. Author (revised by Herner)

A95-87552
COMPUTATIONAL METHODS IN APPLIED SCIENCES; EUROPEAN COMPUTATIONAL FLUID DYNAMICS CONFERENCE, 1ST, BRUSSELS, BELGIUM, SEPT. 7-11, 1992
CH. HIRSCH Vrije Univ. Brussel, Brussels, Belgium, J. PERIAUX Dassault Aviation, Saint-Cloud, France, and E. ONATE Polytechnical Univ. of Catalonia, Barcelona, Spain Amsterdam, The Netherlands Elsevier Science Publishers B.V. 1992 313 p.
(ISBN 0-444-89795-X; HTN-95-61179) Copyright

A conference on computational fluid dynamics and numerical methods in engineering produced on topics that included turbulent flows, combustion, hypersonic reacting flows, atmospheric dispersion, multiphase flows, grid generation and adapation, numerical modeling of composite structures, shape optimization, semiconductors, and domain decomposition methods. For individual titles, see A95-87553 through A95-87567. Herner

A95-87557
NUMERICAL SIMULATION OF THREE-DIMENSIONAL HYPERSONIC REACTING FLOWS OVER BLUNT BODIES WITH CATALYTIC SURFACE
S. V. PEIGIN Tomsk Univ., Tomsk, Russia *In* Computational methods in applied sciences; European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sept. 7-11, 1992 Amsterdam, The Netherlands Elsevier Science Publishers B.V. (ISSN 005) 1992 p. 127-135
(HTN-95-61184) Copyright

The problem of basic characteristic determination for multi-component nonequilibrium dissociated air flow over catalytic surface of blunt body, moving along prescribed aerodynamic reentry trajectory is considered. The effective and economical marches numerical method for solution of three-dimensional viscous shock

layer equations is suggested. It does not need preliminary solution of the Stefan-Maxwell equations with respect to diffusion fluxes and does not imply symmetric planes existence in the flow. The influence of angle of attack, slipping angle, heterogeneous recombination rate and other governing parameters on flow is investigated.
Author (Herner)

A95-87558
NUMERICAL SIMULATION OF REAL GAS EFFECTS AND AERODYNAMIC HEATING OF HYPERSONIC SPACE TRANSPORTATION VEHICLES
YUKIMITSU YAMAMOTO National Aerospace Lab., Tokyo, Japan *In* Computational methods in applied sciences; European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sept. 7-11, 1992. A95-87552 Amsterdam, The Netherlands Elsevier Science Publishers B.V. 1992 p. 137-149
Copyright

Experimental and numerical hypersonic aerodynamic studies of space planes and H-II orbiting Plane (HOPE) have been conducted at National Aerospace Laboratory (NAL) for several years. This paper describes briefly the aerodynamic problems encountered in hypersonic flight of these vehicles. Great emphasis is placed on the analysis of the aerothermodynamic heating and real gas effects, because these problems are main factors which must be resolved in order to make hypersonic flight of aerospace vehicles feasible. Contributions of computational investigations to these problems are presented in detail and further studies necessary for the aerodynamic design of space transportation vehicles are discussed.
Author (Herner)

A95-87559
HIGH-SPEED REACTING FLOW SIMULATION USING USA-SERIES CODES
S. R. CHAKRAVARTHY Rockwell International Science Center, Thousand Oaks, CA, US and S. PALANISWAMY Rockwell International Science Center, Thousand Oaks, CA, US *In* Computational methods in applied sciences; European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sept. 7-11, 1992. A95-87552 Amsterdam, The Netherlands Elsevier Science Publishers B.V. 1992 p. 151-165
Copyright

In this paper, the finite-rate chemistry (FRC) formulation for the USA-series of codes and three sets of validations are presented. USA-series computational fluid dynamics (CFD) codes are based on Unified Solution Algorithms including explicity and implicit formulations, factorization and relaxation approaches, time marching and space marching methodolgies, etc., in order to be able to solve a very wide class of CDF problems using a single framework. Euler or Navier-Stokes equations are solved using a finite-volume treatment with upwind Total Variation Diminishing discretization for the inviscid terms. Perfect and real gas options are available including equilibrium and nonequilibrium chemistry. This capability has been widely used to study various problems including Space Shuttle exhaust plumes, National Aerospace Plane (NASP) designs, etc. (1) Numerical solutions are presented showing the full range of possible solutions to steady detonation wave problems. (2) Comparison between the solution obtained by the USA code and Generalized Kinetics Analysis Program (GKAP) is shown for supersonic combustion in a duct. (3) Simulation of combustion in a supersonic shear layer is shown to have reasonable agreement with experimental observations.
Author (Herner)

A95-87576* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
UNSTEADY PANEL METHOD FOR FLOWS WITH MULTIPLE BODIES MOVING ALONG VARIOUS PATHS
THOMAS F. RICHARDSON San Diego State Univ., San Diego, CA, US, JOSEPH KATZ San Diego State Univ., San Diego, CA, US, and DALE L. ASHBY NASA. Ames Research Center, Moffett Field, CA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 1 January 1994 p. 62-68
(HTN-95-61203) Copyright

A potential flow based three-dimensional panel method was modified to treat time-dependent conditions in which several submerged bodies can move within the fluid along different trajectories. This modification was accomplished by formulating the momentary solution in an inertial frame of reference, attached to the undisturbed stationary fluid. Consequently, the numerical interpretation of the multiple-body, solid-surface boundary condition and the viscous wake rollup was considerably simplified. The usteady capability of this code was calibrated and validated by comparing computed results with closed-form analytical results available for an airfoil, which was impulsively set into a constant speed forward motion. To demonstrate the multicomponent capability, computations were made for two wings following closely intersecting paths (i.e., simulations aimed at avoiding mid-air collisions) and for a flowfield with relative rotation (i.e., the case of a helicopter rotor rotating relative to the fuselage). Computed results for the cases were compared to experimental data, when such data was available.
Author (Herner)

A95-87577* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IMPROVING THE EFFICIENCY OF AERODYNAMIC SHAPE OPTIMIZATION
GREG W. BURGREEN Old Dominion Univ., Norfolk, VA, US, OKTAY BAYSAL Old Dominion Univ., Norfolk, VA, US, and MOHAMED E. ELESHAKY Old Dominion Univ., Norfolk, VA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 1 January 1994 p. 69-76
(Contract(s)/Grant(s): NAG1-1188)
(HTN-95-61204) Copyright

The computational efficiency of an aerodynamic shape optimization procedure that is based on discrete sensitivity analysis is increased through the implementation of two improvements. The first improvement involves replacing a grid-point-based approach for surface representation with a Bezier-Bernstein polynomial parameterization of the surface. Explicit analytical expressions for the grid sensitivity terms are developed for both approaches. The second improvement proposes the use of Newton's method in lieu of an alternating direction implicit methodology to calculate the highly converged flow solutions that are required to compute the sensitivity coefficients. The modified design procedure is demonstrated by optimizing the shape of an internal-external nozzle configuration. Practically identical optimization results are obtained that are independent of the method used to represent the surface. A substantial factor of 8 decrease in computational time for the optimization process is achieved by implementing both of the design procedure improvements.
Author (Herner)

A95-87581
DRAG AND LIFT IN NONADIABATIC TRANSONIC FLOW
GUENTER H. SCHNERR Univ. of Kalsruhe, Karlsruhe, Germany and ULRICH DOHRMANN Univ. of Kalsruhe, Karlsruhe, Germany AIAA Journal (ISSN 0001-1452) vol. 32, no. 1 January 1994 p. 101-107 Research sponsored by DFG and KSB
(HTN-95-61208) Copyright

Transonic flows with heat addition over airfoils have been calculated for different angles of attack. The fluid is a mixture of an inert carrier gas and a small amount of a condensible vapor. For the phase change process coupled to the flow, two limiting cases are investigated: nonequilibrium condensation after significant supersaturation and homogeneous nucleation and equilibrium condensation. Numerical calculations based on the Euler equations are linked with either the classical nucleation theory coupled with microscopic droplet growth laws or an equilibrium process. An improved explicit time-dependent diabatic finite volume method is developed and applied to calculate stationary flows. Reservoir conditions of pressure, temperature, and vapor content are varied to simulate internal flows in transonic wind tunnels, turbomachinery, and atmospheric flight at low altitudes. The pressure drag and the lift may increase or decrease. Homogeneous condensation in internal flows produces a maximum decrease of the pressure drag of about 60% and a maximum lift decrease of 35%.
Author (revised by Herner)

A95-87582
PRESSURE MEASUREMENTS ON A PITCHING AIRFOIL IN A WATER CHANNEL
RAND N. CONGER John Graham Associates, Seattle, WA, US and B. R. RAMAPRIAN Washington State Univ., Pullman, WA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 1 January 1994 p. 108-115 (Contract(s)/Grant(s): AF-AFOSR-90-0131; F49620-92-J-0146) (HTN-95-61209) Copyright

Measurements of unsteady pressures over a symmetric NACA 0015 airfoil performing pitching maneuvers are reported. The tests were performed in an open-surface water channel specially constructed for this purpose. The design of the apparatus allowed the pressure measurements to be made to a very high degree of spatial and temporal resolution. Reynolds numbers in the range of 5.2 x 10(exp 4) to 2.2 x 10(exp 5) were studied. Although the results qualitatively agreed with earlier studies performed at similar Reynolds numbers, the magnitudes of pressure and aerodynamic forces measured were observed to be much larger than those measured in ealier pitchup studies. They were found, in fact, to be closer to those obtained in some recent high-Reynolds-number experiments. This interesting behavior, which was suspected to be caused by the relatively high freestream turbulence level in the water channel, was explored in some detail. In addition, several issues like the quasisteady and dynamic effects of the pitching process are discussed. The experimental data are all archived and are available for use as a database. Author (Herner)

A95-87583
SIMPLE NUMERICAL CRITERION FOR VORTEX BREAKDOWN
B. A. ROBINSON McDonnel Douglas Corp., St. Louis, MO, US, R. M. BARNETT McDonnel Douglas Corp., St. Louis, MO, US, and S. AGRAWAL McDonnel Douglas Corp., St. Louis, MO, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 1 January 1994 p. 116-122 (HTN-95-61210) Copyright

Vortex breakdown is currently identified in numerical flow solutions through postprocessing techniques. Although these methods can identify breakdown accurately, they can involve cumbersome data transfer and processing that can be quite time consuming. Therefore, a simple Rossby number criterion is proposed. The criterion is established using solutions to Euler and Navier-Stokes equations for low-speed flow over a flat-plate delta wing at high angles of attack. Comparison with experimental data shows consistent values of Rossby number at breakdown. The proposed Rossby number criterion provides an efficient means of locating breakdown in numerical solutions. It is also straightforward to incorporate in any flow solver. Author (Herner)

A95-87682* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HEAT-TRANSFER MEASUREMENTS AND COMPUTATIONS OF SWEPT-SHOCK-WAVE BOUNDARY-LAYER INTERACTIONS
Y. LEE Penn Sate Univ., University Park, PA, US, G. S. SETTLES Penn Sate Univ., University Park, PA, US, and C. C. HORSTMAN NASA. Ames Research Center, Moffet Field, CA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 726-734 (Contract(s)/Grant(s): NAG2-592) (HTN-95-81634) Copyright

An experimental and computational research program providing new knowledge of the heat transfer in swept-shock-wave/boundary-layer interactions is described. An equilibrium turbulent boundary layer on a flat plate is subjected to impingement by a swept planar shock wave generated by a sharp fin. Five different interactions with fin angles ranging from 10 to 20 deg at freestream Mach numbers of 3 and 4 produce a variety of interaction strengths ranging from weak to very strong. A foil heater generates a uniform heat flux over the flat plate surface, and miniature thin-film-resistance sensors are used to measure the local surface temperature. The heat convection equation is then solved for the heat transfer distribution within an interaction, yielding an uncertainty of about +/- 10%. These data are compared with numerical Navier-Stokes solutions that employ a k-epsilon turbulence model. A simple peak heat transfer correlation for fin interactions is suggested. Author (Herner)

A95-87685
AUTYOMATED ADAPTIVE TIME-DISCONTINUOUS FINITE ELEMENT METHOD FOR UNSTEADY COMPRESSIBLE AIRFOIL AERODYNAMICS
B. E. WEBSTER Rensselaer Polytechnic Institute, Troy, NY, US, M. S. SHEPHARD Rensselaer Polytechnic Institute, Troy, NY, US, Z. RUSAK Rensselaer Polytechnic Institute, Troy, NY, US, and J. E. FLAHERTY Rensselaer Polytechnic Institute, Troy, NY, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 748-757 (Contract(s)/Grant(s): DAAL-03-88-C-0004) (HTN-95-81637) Copyright

An adaptive finite element methodology for unsteady compressible aerodynamics is presented. The automated adaptive environment consists of the finite quadtree automatic mesh generator, a time-discontinuous Galerkin least-squares finite element flow solver, an error indicator based on interpolation estimates, and a mesh enrichment procedure. Specifically, a linear space-time wedge element formulation was developed and implemented for two-dimensional problems with relative body motion. The mesh enrichment procedure is developed to enable the solution process to be spatially adaptive (h refinement), is edge based, and stores no mesh enrichment history. Unsteady transonic airfoil calculations show good correlation with available experiment data. Author (Herner)

A95-87687* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
PARAMETERS OF NOCILLA GAS/SURFACE INTERACTION MODEL FROM MEASURED ACCOMODATION COEFFICIENTS
FRANK G. COLLINS Univ. of Tennessee, Tullahoma, TN, US and E. C. KNOX Remtech, Inc., Huntsville, AL, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 765-773 (Contract(s)/Grant(s): NAS8-38416) (HTN-95-81639) Copyright

Free-molecule aerodynamic coefficients are computed for a flat plate surface element at various angles of attack using the normal and tangential accomodation coefficients and the Nocilla model of the gas/surface interaction. The Nocilla model assumes that the molecules reflect from a surface in the form of a drifting Maxwellian with a mean velocity at a specific temperature. The computations use curve fits of the angular variation of the existing measurements of the accomodation coefficients and of the parameters in the Nocilla model. The two methods indicate that a surface element has considerably more lift than predicted by an assumption of diffuse scattering. In other respects the predictions by the two methods do not agree. Author (Herner)

A95-87688* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MULTIPOINT INVERSE DESIGN OF AN INFINITE CASCADE OF AIRFOILS
M. S. SELIG Univ. of Illinois, Urbana, IL, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 774-782 (Contract(s)/Grant(s): NGT-50341) (HTN-95-81640) Copyright

This paper describes a method for the design of an infinite cascade in incompressible flow. The method is based on conformal mapping and does not allow for multipoint design. The cascade blade is to determined is divided into a number of segments. Over each segment, the velocity distribution is prescribed together with an inlet or outlet flow angle at which this velocity distributions is to be achieved. In this way multipoint design requirements can be met. It is necessary to satisfy several conditions that arise to guarantee compatibility with the inlet and outlet flow as well as closure of the cascade blade. Satisfaction of these conditions does not necessarily result in a cascade with all of the desired characteristucs. For example, the cascade blades may be bulbous or crossed. Through Newtonian iteration, however, the desired characteristics may be prescribed directly. Four examples will be illustrated to demonstrate the capability of the method. Author (Herner)

A95-87689* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AIRFOIL PRESSURE MEASUREMENTS DURING OBLIQUE SHCOK-WAVE/VORTEX INTERACTION IN A MACH 3 STREAM

I. M. KALKHORAN Polytechnic Univ., Brooklyn, NY, US and P. M. SFORZA Polytechnic Univ., Brooklyn, NY, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 783-788
(Contract(s)/Grant(s): NAG3-1378; F-49620-93-1-0009)
(HTN-95-81641) Copyright

An experimental investigation of the interaction between streamwise discrete vortices and oblique shocks formed over a two-dimensional wedge surface was conducted in a Mach 3 blowdown wind tunnel. An instrumented two-dimensional wedge was placed downstream of a semiispan wing so that the trailing tip vortex would arbitrarily interact with the shock wave formed over the wedge surface. The experiments were designed to simulate interaction of streamwise vortices from upstream bodies with shock waves formed over aft surfaces as might be encountered in supersonic flight of aircraft and missiles. The influence of vortex strength and vortex-airfoil vertical separation distance on the interaction was examined. Author (Herner)

A95-87690

ROLE OF KUTTA WAVES ON OSCILLATORY SHOCK MOTION ON AN AIRFOIL

B. H. K. LEE NRC, Ottawa, Ontario, Canada, H. MURTY NRC, Ottawa, Ontario, Canada, and H. JIANG Queen's Univ., Kingston, Ontario, Canada AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 789-796 Research sponsored by NSERC
(HTN-95-81642) Copyright

An investigation of wave propagation in transonic flows is carried out using the nonlinear transonic small disturbance equation. The wave fronts are computed from numerical integration of the characteristic equation. The manner in which downstream disturbances, initiated at an airfoil trailing egde, travel to the shock wave is analyzed. Through a relation between the amplitude of the disturbance and the magnitude of shock displacement has not yet been derived to study the interaction process, the results presented are sufficient to give a better understanding of the feedback mechanism proposed in an earlier investigation of oscillatory shock motion observed in transonic airfoil buffeting. The propagation time for downstream disturbances to reach the shock wave is computed for various airfoil geometries and freestream Mach numbers. The results are compared with those obtained from an empirical formulation given by Tideman. Author (Herner)

A95-87691

EFFECTS OF TIME SCALES ON LIFT OF AIRFOILS IN AN UNSTEADY STREAM

I. GURSUL Univ. of Cincinnati, Cincinnati, OH, US, H. LIN Univ. of Southern California, Los Angeles, CA, US, and C.-M. HO Univ. of Southern California, Los Angeles, CA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 797-801 Research sponsored by AFOSR
(HTN-95-81643) Copyright

In unsteady aerodynamics,the reduced frequency has always been considered as the predominant controlling parameter because it relates to the unsteadiness. In this study, we examined the responses of several delta wings of varying aspect ratio and a two-dimensional wing in an unsteady periodic freestream. We found that in certain operating conditions, the lift of the airfoils may or may not be the function of the reduced frequency, depending on whether the leading-edge separation vortex can remain stationary on the wing or not. For delta wings with attached, stationary leading-edge vortices, the lift forces are not a function of the reduced frequency. However, if the leading-edge vortices shed and convect downstream, then the lift force depends on the reduced frequency. Author (Herner)

A95-87692

EFFECTS OF TRAILING-EDGE JET ENTRAINMENT ON DELTA WING VORTICES

H. E. HELIN US Air Force Academy, Colorado Springs, CO, US and C. W. WATRY George Washington Univ., Hampton, VA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 802-804
(HTN-95-81644) Copyright

This paper examines the effects of trailing-edge jet entrainment on the streamwise vortices over a delta wing. Although studies have examined the effects of leading-edge suction and blowing on the burst location of delta wing vortices, very little research has focused on the effects of trailing-edge jet exhaustion on the burst location. Using a 60-deg delta wing model in a water tunnel with dye to mark the vortex core, it was possible to visualize how the location of the vortex breakdown changes with trailing edge jet velocity. This research has determined that at moderate angles of attack it is possible to delay the burst location up to 18% of the chord by increasing the flow velocity from the exhaust ports. In addition, at higher angles of attack, the trailing-edge jet stabilized the asymmetric separated vortices by reattaching the flow and moving the burst location aft on the wing. Author (Herner)

A95-87694* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

DYNAMIC-STALL AND STRUCTURAL-MODELING EFFECTS ON HELICOPTER BLADE STABILITY WITH EXPERIMENTAL CORRELATION

D. BARWEY Washington Univ., St. Louis, MO, US and GOPAL H. GAONKAR Florida Atlantic Univ., Boca Raton, FL, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 811-819
(Contract(s)/Grant(s): NAG2-797; DAAL-03-91-G-0007)
(HTN-95-81646) Copyright

The effects of blade and root-flexure elasticity and dynamic stall on the stability of hingeless rotor blades are investigated. The dynamic stall description is based on the ONERA models of lift, drag, and pitching moment. The structural analysis is based on three blade models that range from a rigid flap-lag model to two elastic flap-lag-torsion models, which differ in representing root-flexure elasticity. The predictions are correlated with the measured lag damping of an experimental isolated three-blade rotor; the correlation covers rotor operations from near-zero-thrust conditions in hover to highly stalled, high-thrust conditions in foward flight. That correlation shows sensitivity of lag-damping predictions to structural refinements in blade and root-flexure modeling. Moreover, this sensitivity increases with increasing control pitch angle and advance ratio. For high-advance-ratio and high-thrust conditions, inclusion of dynamic stall generally improves the correlation. Author (Herner)

A95-87695

AEROELASTIC RESPONSE OF COMPOSITE ROTOR BLADES CONSIDERING TRANSVERSE SHEAR AND STRUCTURAL DAMPING

SUNG NAM JUNG Seoul National Univ., Seoul, Korea and SEUNG JO KIM Seoul National Univ., Seoul, Korea AIAA Journal (ISSN 0001-1452) vol. 32, no. 4 April 1994 p. 820-827
(HTN-95-81647) Copyright

The effects of transverse shear deformations and structural damping on the flutter phenomena of a composite rotor blade in hover have been investigated using the finite element method. First-order shear deformation theory with rotary inertia effects and a damped element model of composite laminates are employed for the structural formulation. A quasisteady aerodynamic theory with a dynamic inflow model is used. Torsion-related out-of-plane warping and noncirculatory aerodynamic components are also incorporated in the formulation. Using these structural and aerodynamic tools, several numerical studies are carried out, first to validate the current approach and second to show the effects of transverse shear deformations and structural damping on the aeroelstic stability of a composite rotor as a function of fiber orientation. The predictions derived by the frequency analysis of this model are found to be more accurate than those given by an alternative approach compared with experimental data. It is shown that the transverse shear flexibility tends to lower the frequency of the rotor, and generally has a destabilizing effect on the lag mode and a stabilizing effect on the flap mode. It is also presented that the magnitude of structural damping can be controlled by changing ply orientation angle. Author (Herner)

A95-87794

COMMERCIAL APPLICATIONS FOR MILITARY LASER RADARS

JON GROSSMAN RAND Corp., Santa Monica, CA, US *In* Lasers '92; Proceedings of the International Conference on Lasers and Applications, 15th, Houston, TX, Dec. 7-10, 1992. A95-87708 McLean, VA STS Press (ISSN 0190-4132) 1993 p. 559-561
Copyright

The decline in military funding of laser radar/light detection and ranging (LADAR/LIDAR) work has caused many companies to consider commercial applications for this technology. To be successful, these companies need to find niche markets in which the unique capabilities of LADARs and LIDARs can be utilized in a cost effective manner. This paper summarizes the results of a study which identified two areas, environmental monitoring and avionics, which appear to offer significant commercial opportunities for LADARs and LIDARs. Author (Herner)

A95-87798* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THE DETECTION AND MEASUREMENT OF MICROBURST WIND SHEAR BY AN AIRBORNE LIDAR SYSTEM

PAUL A. ROBINSON Lockheed Engineering and Science Co., Hampton, VA, US, ROLAND L. BOWLES NASA. Langley Research Center, Hampton, VA, US, and RUSSELL TARG Lockheed Missiles and Space Co., Palo Alto, CA, US *In* Lasers '92; Proceedings of the International Conference on Lasers and Applications, 15th, Houston, TX, Dec. 7-10, 1992. A95-87708 McLean, VA STS Press (ISSN 0190-4132) 1993 p. 576-583
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The NASA Lockheed Missiles and Space Company (LMSC) Coherent Lidar Airborne Shear Sensor (CLASS) employs coherent lidar technology as a basis for a forward-looking predictive wind shear detection system. Line of sight wind velocities measured ahead of the aircraft are combined with aircraft state parameters to relate the measured wind change (or shear) ahead of an aircraft to its performance loss or gain. In this way the system can predict whether a shear detected ahead of the aircraft poses a significant threat to the aircraft and provide an advance warning to the flight crew. Installed aboard NASA's Boeing 737 research aircraft, the CLASS system is flown through convective microburst wind shears in Denver, Co., and Orlando, Fl. Some preliminary flight test results are presented. It is seen that the system was able to detect and measure wind shears ahead of the aircraft in the relatively dry Denver environment, but its performance was degraded in the high humidity and heavy rain in Orlando. Author (Herner)

A95-88011

AN INVESTIGATION OF THE ACCURACY OF FEM ANALYSIS OF A GRAPHITE EPOXY BOX BEAM

JAMES DANIEL BALDWIN Lockheed Aeronautical Systems, US and JOHN C. MCWHORTER, III Mississippi State Univ., MS, US (ISSN 0148-7191) 1993 10 p. SAE General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, KS, May 18-20, 1993
(SAE PAPER 931221; HTN-95-11969) Copyright

A carbon fiber-epoxy wing box was constructed in order to study the behavior of a stressed-skin wing structure with anisotropic sandwich skins. Two wing skins, two spars, and three ribs made up the structure. The spars were designed to act primarily as shear webs so that the bending load int he structure would be reacted mainly by tension and compression in the skins. Linear, buckling, and nonlinear NASTRAN finite element solution sequences were implemented in the analysis of the structure. The structure was loaded as a cantilever beam and strain and deflection measurements were recorded. The finite element nonlinear analysis accurately modeled stiffness, but results for strains at a point were not as accurate. Author (Herner)

A95-88083

VORTEX CUTTING BY A BLADE, PART 1: GENERAL THEORY AND A SIMPLE SOLUTION

J. S. MARSHALL University of Iowa, Iowa City, IA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 6 June 1994 p. 1145-1150
(Contract(s)/Grant(s): DAAL03-92-0277)
(HTN-95-20822) Copyright

A simplified theory for long-wave motion of vortex filaments with variable core radius is given, for small values of the ratio epsilon = max(sigma/L) of core radius sigma to axial length scale L, which offers a number of advantages for numerical computations of the vortex response. An analytical solution of this theory is then obtained for the axial flow within a straight vortex filament following cutting of the vortex by a flat blade at an angle of attack alpha. The mathematical structure of the solution is similar to the classic problem of impulsive piston motion in a shock tube, and analogies of shocks and expansion waves propagating on the vortex away from the blade are predicted. A simple expression for the vortex force on the blade is derived, which is found to be mainly dependent on the ratio of the vortex core radii on opposing sides of the blade. Author (Herner)

A95-88084* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

FLUCTUATING WALL PRESSURES NEAR SEPARATION IN HIGHLY SWEPT TURBULENT INTERACTIONS

J. D. SCHMISSEUR Wright-Patterson AFB, Dayton, OH, US and D. S. DOLLING University of Texas, Austin, TX, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 6 June 1994 p. 1151-1157
Research sponsored by USAF Palace Knight Program
(Contract(s)/Grant(s): NAG2-1005)
(HTN-95-20823) Copyright

Fluctuating wall pressures have been measured in Mach 5 interactions generated by sharp, upswept fins at angles of attack of 16 to 28 deg. The results show that rms pressure distributions, like the mean, can be collapsed in conical coordinates. The wall pressure signal near separation is intermittent and is qualitatively similar to that measured in unswept interactions and other swept flows. However, the dominant separation shock frequencies in the swept flows are up to an order of magnitude higher than those in unswept interactions under identical incoming flow conditions. In light of the present observations, it appears that an earlier remark, by Gilson and Dolling, that separation is characterized by a shuddering compression system, in contrast to a translating separation shock is erroneous due to a combination of weak shock strength and inadequate spatial resolution. Furthermore, although the maximum rms pressure near separation increases with increasing interaction strength, as in swept compression ramp flows, comparison of data from the two flow types indicates that the appropriate correlating parameter is the interaction sweepback angle. Author (Herner)

A95-88086

THREE-DIMENSIONAL ADAPTIVE GRID-EMBEDDING EULER TECHNIQUE

ROGER L. DAVIS United Technologies Research Center, East Hartford, CT, US and JOHN F. DANNENHOFFER, III United Technologies Research Center, East Hartford, CT, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 6 June 1994 p. 1167-1174
Research Sponsored by United Technologies Corp.
(HTN-95-20825) Copyright

A new three-dimensional adaptive-grid Euler procedure is presented that automatically detects high-gradient regions in the flow and locally subdivides the computational grid in these regions to provide a uniform, high level of accuracy over the entire domain.

A tunable, semistructured data system is utilized that provides global topological unstructured-grid flexibility along with the efficiency of a local, structured-grid system. In addition, this structure data allows for the flow solution algorithm to be executed on a wide variety of parallel/ vector computing platforms. An explicit, time-marching, control volume procedure is used to integrate the Euler equations to a steady state. In addition, a multiple-grid procedure is used throughout the embedded-grid regions as well as on subgrids coarser than the initial grid to accelerate convergence and properly propagate disturbance waves through refined-grid regions. Upon convergence, high flow gradient regions, where it is assumed that large truncation errors in the solution exist, are detected using a combination of directional refinement vectors that have large components in areas of these gradients. The local computational grid is directionally subdivided in these regions and the flow solution is reinitiated. Overall convergence occurs when a prespecified level of accuracy is reached. Solutions are presented that demonstrate the efficiency and accuracy of the present procedure. Author (Herner)

A95-88090

BOUNDARY CONDITIONS FOR UNSTEADY SUPERSONIC INLET ANALYSES

DAVID W. MAYER Boeing Commercial Airplane Group, Seattle, WA, US and GERALD C. PAYNTER Boeing Commercial Airplane Group, Seattle, WA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 6 June 1994 p. 1200-1206

(HTN-95-20829) Copyright

New bleed and compresor face boundary conditions have been developed to improve the accuracy of unsteady supersonic inlet calculations. The new bleed boundary condition relates changes in the bleed hole discharge coefficient to change the local flow conditions; the local bleed flow rate can more than double as a shock moves forward over a bleed band in response to inlet flow disturbances. The stability margin of the inlet is strongly dependent on the throat bleed configuration since the locally rapid increase in bleed flow has a stong effect on the motion of the normal shock. The new compressor face boundary condition accounts for changes in the unsteady flow conditions at the compressor face by specifying the compressor face corrected mass flow or Mach number either as a constant or as a linear function of the stagnation conditions. The effects of inlet flow disturbances on the flow at the compressor face are represented more realistically with this new boundary condition than with traditional fixed static pressure or mass flow conditions. Euler calculations of the dynamic response of an inlet flow to a flow disturbance at the compressor face with 20- and 90-deg throat bleed hole angles are reported. These results indicate that an extra margin of stability for the inlet is obtained with 90-deg bleed holes because the increase in bleed flow rate as the shock moves forward over a bleed is much larger for 90-deg holes than for 20-deg holes.

Author (Herner)

A95-88093* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

LOW-DIMENSIONAL DESCRIPTION OF THE DYNAMICS IN SEPARATED FLOW PAST THICK AIRFOILS

ANIL E. DEANE NASA Goddard Space Flight Center, Greenbelt, MD, US and CATHERINE MAVRIPLIS George Washington University, Washington, DC, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 6 June 1994 p. 1222-1227

(HTN-95-20832) Copyright

Results are presented for the numerical simulation of unsteady viscous incompressible flow past thick airfoils. Specifically, flow past a NACA 4424 at an angle of attack of 2.5 deg and Reynolds numbers in the range of 1700-4000 has been simulated using the spectral element method. At these conditions the flow is separatedd and an unsteady wake is formed. Application of the method of empirical eigenfunction reveals the structure of the most energetic components of the flow. These are found to occur in pairs that, through phase exchange, are responsible for the vortex shedding. A set of ordinary differential equations is obtained for the amplitudes of these eigenfunctions by a Galerkin projection of the Navier-Stokes equations. The solutions of the model system are compared with the full simulation. The work is of relevance to the transition process and observed routes to chaos in airfoil wakes.

Author (Herner)

A95-88095* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

LASER INTERFEROMETER SKIN-FRICTION MEASUREMENTS OF CROSSING-SHOCK-WAVE/ TURBULENT-BOUNDARY-LAYER INTERACTIONS

T. J. GARRISON Pennsylvania State University, University Park, PA, US, G. S. SETTLES Pennsylvania State University, University Park, PA, US, N. NARAYANSWAMI Rutgers University, Piscataway, NJ, US, and D. D. KNIGHT Rutgers University, Piscataway, NJ, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 6 June 1994 p. 1234-1241

(Contract(s)/Grant(s): NGT-50952; AF-AFOSR-89-0315)

(HTN-95-20834) Copyright

Wall shear stress measurements beneath crossing-shock-wave/turbulent boundary-layer interactions have been made for three interactions of different strengths. The interactions are generated by two sharp fins at symetric angles of attack mounted on a flat plate. The shear stress measurements were made for fin angles of 7 and 11 deg at Mach 3 and 15 deg at Mach 3.85. The measurements were made using a laser interferometer skin-friction meter, a device that determines the wall shear by optically measuring the time rate of thinning of an oil film placed on the test model surface. Results of the measurements reveal high skin-friction coefficients in the vicinity of the fin/plate junction and the presence of quasi-two-dimensional flow separation on the interaction center line. Additionally, two Navier-Stokes computations, one using a Baldwin-Lomax turbulence model and one using a k-epsilon model, are compared with the experimental results for the Mach 3.85, 15-deg interaction case. Although the k-epsilon model did a reasonable job of predicting the overall trend in portions of the skin-friction distribution, neither computation fully captured the physics of the near-surface flow in this complex interaction. Author (Herner)

A95-88096* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AERODYNAMIC INVESTIGATION WITH FOCUSING SCHLIEREN IN A CRYOGENIC WIND TUNNEL

EHUD GARTENBERG Old Dominion University, Norfolk, VA, US, LEONARD M. WEINSTEIN NASA Langley Research Center, Hampton, VA, US, and JR. LEE EDWIN E. NASA Langley Research Center, Hampton, VA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 6 June 1994 p. 1242-1249

(Contract(s)/Grant(s): NAS1-18584-151)

(HTN-95-20835) Copyright

A flow visualization study was performed using a focusing schlieren system in the 0.3m Transonic Cryogenic Tunnel at NASA Langley Research Center. The system proved to be a useful flow visualization tool for flows as low as M = 0.4. This study marked the first verification of the focusing schlieren technique in a major subsonic/transonic wind tunnel and the first time that high-quality, detailed pictures of high-Reynolds-numbers flows were obtained in a cryogenic wind tunnel. This test was part of a development program to implement instrumentation techniques in cryogenic wind tunnels, with the ultimate aim to use them in the National Transonic Facility (NTF). Author (Herner)

A95-88105* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

CHEMICAL RECOMBINATION IN AN EXPANSION TUBE

ROBERT J. BAKOS University of Queensland, Brisbane, Queensland, Australia and RICHARD G. MORGAN University of Queensland, Brisbane, Queensland, Australia AIAA Journal (ISSN 0001-1452) vol. 32, no. 6 June 1994 p. 1316-1318

(Contract(s)/Grant(s): NAGW-674)

(HTN-95-20844) Copyright

The note describes the theoretical basis of chemical recombination in an expansion tube which simulates energy, Reynolds number, and stream chemistry at near-orbital velocities. Expansion tubes can satisfy ground-based hypersonic propulsion and aerothermal testing requirements. Herner

A95-88106* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SENSITIVITY DERIVATIVES FOR THREE DIMENSIONAL SUPERSONIC EULER CODE USING INCREMENTAL ITERATIVE STRATEGY

VAMSHI MOHAN KORIVI Old Dominion University, Norfolk, VA, US, ARTHUR C. TAYLOR, III Old Dominion University, Norfolk, VA, US, PERRY A. NEWMAN NASA Langley Research Center, Hampton, VA, US, and HENRY E. JONES NASA Langley Research Center, Hampton, VA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 6 June 1994 p. 1319-1321
(Contract(s)/Grant(s): NAG1-1265)
(HTN-95-20845) Copyright

In a recent work, an incremental strategy was proposed to iteratively solve the very large systems of linear equations that are required to obtain quasianalytical sensitivity derivatives from advanced computational fluid dynamics (CFD) codes. The technique was sucessfully demonstrated for two large two-dimensional problems: a subsonic and a transonic airfoil. The principal feature of this incremental iterative stategy is that it allows the use of the identical approximate coefficient matrix operator and algorithm to solve the nonlinear flow and the linear sensitivity equations; at convergence, the accuracy of the sensitivity derivatives is not compromised. This feature allows a comparatively straightforward extension of the methodology to three-dimensional problems; this extension is successfully demonstrated in the present study for a space-marching solution of the three-dimensional Euler equations over a Mach 2.4 blended wing-body configuration. Author (Herner)

A95-88107

SWIRL CONTROL IN AN S-DUCT AT HIGH ANGLE OF ATTACK

P. F. WENG Shanghai Jiao Tong University, Shanghai, China and R. W. GUO Nanjing University of Aeronautics and Astronautics, Nanjing, China AIAA Journal (ISSN 0001-1452) vol. 32, no. 6 June 1994 p. 1321-1322
(HTN-95-20846) Copyright

A difficult design problem occurs with military aircraft where the inlet is located in an offset position. The problem of angular swirl flow in an S-shaped inlet without guide vanes has come to the fore in the past several years. Many possible modifications of the inlet geometry have been used in the reduction of swirl. Prior work by Guo and Seddon has shown that a large vortex occurs because of flow separation on the bottom wall near the duct throat which produces a large swirl at the engine face. In the prior work, two devices for swirl control were used; one is the solid spoiler, the other is auxiliary inflow by blowing (auxiliary inflow was found to have adverse effects on the flow and pressure recovery characteristics at lower angles of attack). Seddon tested the effect of bottom wall and sidewall fences of various sizes and combinations in reducing the swirl of an S-duct at a 30-deg angle of attack. Tests of Vakili et al. explored the improvement of the secondary flow in an S-duct at 0-deg incidence by using a vortex generator or a flow control rail. The present authors proposed an automatically adjustable blade (AAB) method. The AAB was located inside the duct, and the function relating angle of attack and the optimized angle of the fix (where the duct swirl disappears) was determined. The measurements reviewed in the preceding would be invalid or would produce a large total pressure loss when an S-shaped inlet is at a high angle of attack. The flow distortion and duct swirl increase with increasing the angle of attack (up to 80 deg or 115 deg). This paper describes an improvement of a severely distorted swirl flow in an S-shaped duct at very high angle of attack using a variable lip technique. Author (Herner)

A95-88184

'GLOBAL AVIONICS IN THE FUTURE' REPORT FROM THE 10TH ANNUAL BATTERY CONFERENCE

HENRY OMAN IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985) vol. 10, no. 4 April 1995 p. 14-19 refs
(BTN-95-EIX95282706404) Copyright

In the 10th Annual Battery Conference on Applications and Advances, over 300 came to witness 13 technical sessions on subjects ranging from 'green' batteries to spacecraft batteries, and from batteries for notebook computers to batteries for supplying Alaskan villages with peak power. The utilities will use batteries for energy storage, resource conservation, power-quality involvement, and a substitute for spinning reserve. Those who have attended were electrical engineers who wanted to learn about batteries and electrochemist who wanted to learn how a battery is used and controlled. EI

A95-88789

ANALYTICAL DEVELOPMENTS IN SUPPORT OF THE NASA AGING AIRCRAFT PROGRAM WITH AN APPLICATION TO CRACK GROWTH FROM RIVETS

DANIEL SWENSON Kansas State Univ., Kansas, US, SUDHIR GONDHALEKAR National Semiconductor, US, and DAVE DAWICKE Analytical Services and Materials, US (ISSN 0148-7191) 1993 8 p. SAE General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, Kansas, May 18-20, 1993
(SAE PAPER 931223; HTN-95-71450) Copyright

The NASA Airframe Structural Integrity Program is a multidisciplinary program to develop analysis methodology, a fracture data base, and improved methods of nondestructive evaluation (NDE) detection of disbonds and cracks. As part of this program, analysis tools to predict crack growth rates and fracture propagation in shell structures are being developed. This paper describes a finite element model of crack growth in layered structures, such as lap splice joints. The model is developed using separate two-dimensional meshes of individual layers which can overlap in space. These layers can be connected with either rivit elements or by adhesive elements. Cracks can be modeled in any layer, with automatic remeshing during crack growth. Using the model, an investigation was made of the effect of rivet interference on fatigue crack growth from a loaded rivit hole. It was found that the interference reduced the stress intensity factor range significantly, resulting in slower crack growth. Author (Herner)

A95-88955

A METHOD FOR DISBOND DETECTION IN THERMAL TOMOGRAPHY BY DOMAIN DECOMPOSITION METHOD

FUMIO KOJIMA Osaka Institute of Technology, Japan *In* Inverse problems in engineering mechanics; Intl. Union of Theoretical and Applied Mechanics (IUTAM) Symposium, Tokyo, 1992. A95-88904 Berlin Springer-Verlag 1993 p. 517-525
Copyright

A computational method for the disbond detection in aircraft lap joints and in the adhesive joints between aircraft skin and reinforcing doublers is considered using thermographical data. An idea related to the method of mappings applies to a parameter estimation problem for a 2-D heat diffusion system. A new computational algorithm for estimating the length of disbond is proposed based on the domain decomposition method. Author (Herner)

A95-88979

LIFT ANALYSIS OF A VARIABLE CAMBER FOIL USING THE DISCRETE VORTEX-BLOB METHOD

B. J. MACLEAN University of Utah, Salt Lake City, UT, US and R. A. DECKER University of Utah, Salt Lake City, UT, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1525-1527
(HTN-95-20940) Copyright

Recent research activities in the area of active or smart material systems have generated significant interest to develop adaptive lifting surfaces for advanced aircraft and submarine structures. By using integrated actuators and sensors, advanced problems are

being addressed in aeroelastic tailoring, vibration and attitude control, and high lift devices. An analysis technique is required which can model separated flow at high Reynolds numbers and provide pressure distributions for structure and control system design. The purpose of this Note is to present use of a discrete vortex-blob method to compare lift performance between fixed and variable camber NACA 0012 foils at a Reynolds number of 10(exp 7) for incompressible flow in two dimensions. The vortex method provides a natural and numerically efficient description of eddies and the vorticity they carry. Since a large number of discrete vortex blobs are used to produce a vorticity field in a Lagrangian reference frame, the method becomes grid free and allows modeling of unsteady flows even around multi- element bodies of arbitrary shape (conformal mappings are not involved) in nonuniform motion or rotation.
Author (revised by Herner)

A95-88988
NUMERICAL COMPUTATIONS OF SUPERSONIC BASE FLOW WITH SPECIAL EMPHASIS ON TURBULENCE MODELING
JUBARAJ SAHU U.S. Army Research Laboratory, Aberdeen, MD, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1547-1549
(HTN-95-20949) Copyright
One of the important parameters in the design of shells is the total aerodynamic drag. The base drag component is a large part and can be as high as 50% or more of the total drag. Therefore, it is necessary to predict the base pressure as accurately as possible. The ability to compute the base region flowfield for projectiles using Navier-Stokes computational techniques has been developed. The basic configuration used in this study is a cylindrical afterbody. Numerical flowfield computations have been performed at M(sub infinity) = 2.46 and at 0-deg angle of attack. Various turbulence models (two algebraic models and a two-equation model) are used in the base flow region. Details of the flowfield such as the Mach number contours and base pressure distributions are presented. Computed base pressure distributions are compared with available experimental data for the same conditions and the same configuration. Author (revised by Herner)

A95-88989
PLANAR AIR DENSITY MEASUREMENTS NEAR MODEL SURFACES BY ULTRAVIOLET RAYLEIGH/RAMAN SCATTERING
G. GRUENEFELD Laser-Laboratorium Goettingen, Goettingen, Germany, V. BEUSHAUSEN Laser-Laboratorium Goettingen, Goettingen, Germany, and P. ANDRESEN University of Bielefeld, Bielefeld, Germany AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1457-1463
(HTN-95-20950) Copyright
The feasibility of planar ultraviolet laser-induced Rayleigh and Raman scattering for measurements of small air density variations near model wing surfaces is tested for applications in wind tunnels. Variations in air density of less than 1% are measured quantitatively by Rayleigh scattering in a plane of 3 X 6 cm(exp 2) in about 1 s under the extreme condition in which the laser directly irradiates the metal surface of the wing. Raman scattering was tested as well because it is much less affected by surface and Mie scattering. Therefore, it can be used for density measurements much closer to the model surface and under the presence of dust and droplets with a precision of at least 2%. Further improvements of the measurement precision are possible and will be discussed. Author (Herner)

A95-88991
AEROELASTIC STABILITY OF HINGELESS ROTOR BLADE IN HOVER USING LARGE DEFLECTION THEORY
MAENG HYO CHO Korea Advanced Institute of Science and Technology, Taejon, Korea and IN LEE Korea Advanced Institute of Science and Technology, Taejon, Korea AIAA Journal (ISSN 0001-1452) vol. 32, no. 7 July 1994 p. 1472-1477
(HTN-95-20952) Copyright
The coupled flap-lag-torsion aeroelastic stability of a hingeless rotor blade in hover is investigated using finite elements based on large deflection beam theory. The finite element equations of motion for beams undergoing arbitrary large displacements and rotations, but small strains, are obtained from Hamilton's principle. The stability boundary is calculated assuming blade motions to be small perturbations about the nonlinear steady equilibrium deflections, which are obtained through an iterative Newton-Raphson method. The p-k modal flutter analysis based on coupled rotating natural modes is used. Various unsteady two-dimensional strip theories are used to evaluate the aerodynamic loads. The sensitivity of the stability boundary to these aerodynamic assumptions is examined. Numerical results of the steady deflections and stability boundaries are presented for some representative blade configurations and also compard with those given in previous moderate deflection type theories. Author (Herner)

A95-89183
COMPRESSIBLE NAVIER-STOKES CALCULATIONS OF THE FLOW OVER AIRFOIL SECTIONS. COMPARISONS OF 1ST AND 2ND ORDER TURBULENCE MODELS
BERTRAND MASSON Hispano-Suiza, Harfleur, France, GEORGE HUANG Eloret Inst., Palo Alto, CA, US, and PETER BRADSHAW Stanford Univ., Stanford, CA, US (ISSN 0148-7191) 1993 10 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993 Research sponsored by Aerospatiale
(SAE PAPER 932510; HTN-95-A1463) Copyright
We present preliminary results from a study of the ability of various turbulence models to predict airfoil stall angle, as compared with one of the few modern data sets, from tests of the Aerospatiale airfoil AS240 in the ONERA wind tunnel of Fauga, France. We first compared the Chien k-epsilon model, the Wilcox k-omega model, and the most recent version of the Launder-Reece-Rodi Reynolds-Stress Transport Model (RSTM), in a boundary layer in zero pressure gradient. The k-omega model and the RSTM models were chosen for the airfoil calculations. Author (Herner)

A95-89899
BLADE-BY-BLADE TIP CLEARANCE MEASUREMENT SYSTEM FOR GAS TURBINE APPLICATIONS
A. G. SHEARD Rotadata Ltd, Derby, United Kingdom and B. KILLEEN Journal of Engineering for Gas Turbines and Power, Transactions of the ASME (ISSN 0742-4795) vol. 117, no. 2 April 1995 p. 326-331 refs
(BTN-95-EIX95292721167) Copyright
It is difficult to make a reliable measurement of running clearance in the hostile environment over the blading of a modern gas turbine. When engine manufacturers require the measurement to be made over every blade during live engine tests, system reliability, ruggedness, and ease of operation are of primary importance. This paper describes a tip clearance measurement system that can measure clearance over every blade around a rotor. The measurement system concept is presented, and the system design described in detail. Commissioning of the measurement system on a compressor test facility, and the results obtained are discussed. An analysis of system performance during the commissioning trials concludes the paper. Author (EI)

A95-89904
EXPERIMENTAL INVESTIGATION OF THERMOELASTIC DEFORMATION IN TURBOJET-ENGINE BEARINGS UNDER MAINTENANCE INSPECTION
A. J. KOCHEVAR Oklahoma City Air Logistics Cent, Tinker Air Force Base, OK, United States and C. W. BERT Journal of Engineering for Gas Turbines and Power, Transactions of the ASME (ISSN 0742-4795) vol. 117, no. 2 April 1995 p. 371-376 refs
(BTN-95-EIX95292721173) Copyright
The present investigation examined the vertical and horizontal thermoelastic changes in the outside diameter of a turbojet-engine roller bearing. Thermal loads were imparted to the bearing by the hands of a bearing technician during a rework operation. A worst-case analysis was examined by assuming a three-minute dwell time

and diametrically symmetric thermal loading. Contact temperature was experimentally determined and used in conjunction with a numerical model to simulate thermal propagation throughout the bearing outer ring. Diametric deflection data, obtained using the contact temperature in conjunction with analytic and finite elements, have been shown for comparative purposes. Experimental diametric expansions of the bearing outer ring were determined and compared with the predicted results. Assuming a worst-case scenario, this investigation yielded vertical expansions in the bearing outer ring's diameter, which would be problematic for some bearings during the rework operation; appropriate corrective action was discussed.
Author (EI)

A95-90052
ADVANCES IN THE APPLICATION OF LASER CUTTING, DRILLING, AND WELDING AEROSPACE PARTS
TERRY L. VANDERWERT Lumonics Corp., US (ISSN 0148-7191) 1993 4 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993 (SAE PAPER 932544; HTN-95-A1477) Copyright

Multi-axis laser materials processing systems are having a significant impact on the way aircraft and turbine engine parts are being cut, drilled, and welded is based in the ability to concentrate laser energy into a small area and to produce features having narrow heat affected zones. This paper uses case studies of current users of laser processing systems to report on recent advances in both the understanding of laser materials processing and the control of these processes. Author (revised by Herner)

A95-90054* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
BOUNDARY-LAYER TRANSITION AND GLOBAL SKIN FRICTION MEASUREMENT WITH AN OIL-FRINGE IMAGING TECHNIQUE
DARYL J. MONSON NASA. Ames Research Center, Moffett Field, CA, US, GEORGE G. MATEER NASA. Ames Research Center, Moffett Field, CA, US, and FLORIAN R. MENTER NASA. Ames Research Center, Moffett Field, CA, US (ISSN 0148-7191) 1993 15 p. SAE, Aerotech '93, Costa Mesa, CA, Sep. 27-30, 1993 (SAE PAPER 932550; HTN-95-A1479) Copyright

A new oil-fringe imaging skin friction (FISF) technique to measure skin friction on wind tunnel models is presented. In the method used to demonstrate the technique, lines of oil are applied on surfaces that connect the intended sets of measurement points, and then a wind tunnel is run so that the oil thins and forms interference fringes that are spaced proportional to local skin friction. After a run the fringe spacings are imaged with a CCD-array digital camera and measured on a computer. Skin friction and transition measurements on a two-dimensional wing are presented and compared with computational predictions. Author (Herner)

A95-90267
LASER VELOCIMETRY AND BLADE PRESSURE MEASUREMENTS OF A BLADE-VORTEX INTERACTION
SUSAN ALTHOFF GORTON U.S. Army, Hampton, VA, US, DAVID R. POLING Boeing Defense and Space Group, Philadelphia, PA, US, and LEO DADONE Boeing Defense and Space Group, Philadelphia, PA, US American Helicopter Society, Journal (ISSN 0002-8711) vol. 40, no. 2 April 1995 p. 15-23 (HTN-95-01081) Copyright

An investigation of the flowfield chracteristics around a rotor blade during a blade-vortex interaction (BVI) was conducted at the NASA Langley Research Center by the Army's Aeroperformance Division and the Boeing Defense and Space Group, Helicopter Division, during a wind-tunnel test in the 14 by 22-foot Subsonic Tunnel. A two-component laser velocimeter was used to measure the blade pressure during a BVI. This paper presents velocity measurements that indicate the presence of a vortex in the streamlines and vectors of the induced velocity, when studied in conjunction with the blade surface pressures, indicate how the flowfield is behaving during a BVI. The following conclusions can be made from this investigation: (1) The streamlines and vectors of the induced velocity, when studied in conjunction with the blade surface pressures, indiacte how the flowfield is behaving during a BVI. The blade approaches and intersects a vortex, and the vortex slides beneath the blade. (2) The data provide detailed flowfield information for validating computational predictions of BVI and also for evaluating and improving current wake models. Among the options investigated, only the free-wake calculation by TECH-01 indicated any BVI activity in the first quadrant. Author (Herner)

A95-90284
PRELIMINARY REULTS FROM A PARTICLE IMAGE VELOCIMETRY STUDY OF BLADE-VORTEX INTERACTION
M. B. HORNER University of Galsgow, Glasgow, Scotland, UK, J. N. STEWART Heriot-Watt University, Edinburgh, Scotland, UK, R. A. MCD. GALBRAITH University of Galsgow, Glasgow, Scotland, UK, I. GRANT Heriot-Watt University, Edinburgh, Scotland, UK, F. N. COTON University of Galsgow, Glasgow, Scotland, UK, and G. H. SMITH Heriot-Watt University, Edinburgh, Scotland, UK Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 983 March 1995 p. 91-98 Research supported by the British Ministry of Defence, the Defence Research Agency and the University of Colorado (HTN-95-01098) Copyright

The results of a blade-vortex interaction (BVI) study incorporating particle image velocimetry (PIV) are presented. Test cases encompass a variety of intersection geometries, including head-on parallel interactions. Results provide quantified flow visualization images of the flows generated near the blade tip and inboard during interactions. PIV results are examined in the light of understanding gained from previous pressure measurements made from the same BVI facility. Both the difficulties and the advantages of utilizing the PIV technique in this application are discussed. Author (Herner)

A95-90452
ABLATIVE THERMAL MANAGEMENT STRUCTURAL MATERIAL ON THE HYPERSONIC VEHICLES
H. SHORTLAND Rockwell International Corporation, Seal Beach, California, US and C. TSAI Rockwell International Corporation, Seal Beach, California, US 1995 5 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(AIAA PAPER 95-6133; HTN-95-B0371) Copyright

A hypersonic vehicle is designed to fly at high Mach number in the earth's atmosphere that will result in higher aerodynamic heating loads on specific areas of the vehicle. A thermal protection system is required for these areas that may exceed the operating temperature limit of structural materials. This paper delineates the application of ablative material as the passive type of thermal protection system for the nose or wing leading edges. A simplified quasi-steady-state one-dimensional computer model was developed to evaluate the performance and thermal design of a leading edge. The detailed description of the governing mathematical equations and results are presented. This model provides a quantitative information to support the design estimate, performance optimization, and assess preliminary feasibility of using ablation as a design approach. Author (Herner)

A95-90559* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
RESEARCH ACTIVITY AT THE SHOCK TUBE FACILITY AT NASA AMES
SURENDRA P. SHARMA NASA. Ames Research Center, Moffett Field, CA, US *In* Proceedings of the International Workshop on Strong Shock Waves, Chiba, Japan, July 18-20, 1991. A95-90558 Tokyo, Japan Seishosha, Co., Ltd. March 1992 p. 1-21 Copyright

The real gas phenomena dominate the relaxation process occurring in the flow around hypersonic vehicles. The air flow around these vehicles undergoes vibrational excitation, chemical dissociation, and ionization. These chemical and kinetic phenomena absorb energy, change compressibility, cause temperature to fall, and density to rise. In high-altitude, low density environments, the characteristic thicknesses of the shock layers can be smaller than the relaxation distances required for the gas to attain chemical and thermodynamic equilibrium. To determine the effects of chemical nonequilibrium over a realistic hypersonic vehicle, it would be desirable to conduct an experiment in which all aspects of fluid flow are simulated. Such an experiment is extremely difficult to setup. The only practical alternative is to develop a theoretical model of the phenomena and to compute the flow around the vehicle including the chemical nonequilibrium, and compare the results with the experiments conducted in the facilities under conditions where only a portion of the flow phenomena is simulated. Three types of experimental data are needed to assist the aerospace community in this model development process: (1) data which will enhance our phenomenological understanding of the relaxation process, (2) data on rate reactions for the relevant reactions, and (3) data on bulk properties, such as spectral radiation emitted by the gas, for a given set of aerodynamic conditions. NASA Ames is in a process of collecting such data by simulating the required aerothermochemical conditions in an electric arc driven shock tube. Author (Herner)

A95-90575

NUMERICAL STUDIES OF MACH REFLECTION WITH AIR CHEMISTRY

A. HANAMITSU Kawasaki Heavy Industries, Ltd., Gifu, Japan and M. NISHIDA Kyushu University, Fukuoka, Japan In Proceedings of the International Workshop on Strong Shock Waves, Chiba, Japan, July 18-20, 1991. A95-90558 Tokyo, Japan Seishosha, Co., Ltd. March 1992 p. 207-212

Copyright

A numerical simulation was performed for the chemical equilibrium flow ingested into an inlet placed in a hypersonic flow using TVD-MacCormack scheme. The calculations were carried out for a free stream Mach number 15 with atmospheric conditions at an altitude of 45 km. In the present work, we adopted the equivalent gamma and the simplified curve fits for the thermodynamic properties of equilibrium air. This made it possible to use the existing code for the perfect gas with little modification. From the results of computed axisymmetric inlet flows, it has been seen that the chemical equilibrium flow has a very complicated flow field in large ratios of an inlet radius to a duct wall thickness, which was not observed in the perfect gas flow. In the two-dimensional inlet flow, this complicated flow field was not observed even in the chemical equilibrium flow. Author (Herner)

A95-90920

IMPULSE RADIATING ANTENNAS

CARL E. BAUM Phillips Lab., Kirtland, NM, US and EVERETT G. FARR Farr Research, Albuquerque, NM, US *In* Ultra-wideband, short-pulse electromagnetics; WRI International Conference, 2nd, Brooklyn, NY, October 8-10, 1992. A95-90904 New York, NY Plenum Press January 1993 p. 139-147

Copyright

A number of applications require radiation of a short pulse of electromagnetic energy out to large distances. These applications include target discrimination in a cluttered environment (e.g., looking over the ocean), aircraft identification by taking a 'TDR' of its major scattering centers, and target location through foliage. The Impulse Radiating Antenna (IRA) has generated widespread interest for its ability to radiate a broadband pulse. The purpose of this paper is to summarize recent work on Impulse Radiating Antennas. Author (Herner)

A95-90924

POLARIZATION DIVERSE ULTRA-WIDEBAND ANTENNA TECHNOLOGY

MICHAEL C. WICKS Rome Lab., NY, US and PAUL ANTONIK Kaman Sciences Corp., Utica, NY, US *In* Ultra-wideband, short-pulse electromagnetics; WRI International Conference, 2nd, Brooklyn, NY, October 8-10, 1992. A95-90904 New York, NY Plenum Press January 1993 p. 177-187

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This paper presents an ultra-wideband (UWB) antenna design that is capable of multiple polarizations. The multiple element design provides polarization diversity while maintaining desirable phase and standing wave characteristics. The prospect of replacing multiple single purpose antennas on a modern military platform with a single antenna capable of wideband and multi-function operation is of significant interest. Considering space availability, maintenance simplification and aerodynamics, antenna count is now carefully considered in the planning of each new aircraft and space vehicle and in many modification of existing equipment. The broadband radiation capability of this antenna together with its polarization and phase characteristics suggest the possibility of its service in such applications. This antenna can also be of use in other environments such as satellite communications for both the orbital vehicle and the earthbound receptor functions. In the latter, the earthbound satellite receptor use of this antenna can be supplemented with a parabolic dish or other reflector arrangement. Author (Herner)

A95-91479* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

PARALLEL COMPUTATIONAL FLUID DYNAMICS '91; CONFERENCE PROCEEDINGS, STUTTGART, GERMANY, JUN. 10-12, 1991

K. G. REINSCH, editor, W. SCHMIDT, editor, A. ECER, editor Indiana Univ.-Purdue Univ., Indianapolis, IN, US, JOCHEM HAEUSER, editor European Space Research and Technology Center, ESA, Noordwijk, Netherlands, and J. PERIAUX, editor Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 353 p.

(ISBN 0-444-89363-6; HTN-95-A1597) Copyright

A conference was held on parallel computational fluid dynamics and produced related papers. Topics discussed in these papers include: parallel implicit and explicit solvers for compressible flow, parallel computational techniques for Euler and Navier-Stokes equations, grid generation techniques for parallel computers, and aerodynamic simulation om massively parallel systems. For individual titles, see A95-91480 through A95-91490. Herner

A95-91482

IMPLICIT MULTI-DOMAIN METHOD FOR UNSTEADY COMPRESSIBLE INVISCID FLUID FLOWS AROUND 3D PROJECTILES

C. BOREL Matra Defense, Velizy, France and F. X. ROUX ONERA, Chatillon, France *In* Parallel computational fluid dynamics '91; Conference Proceedings, Stuttgart, Germany, Jun. 10-12, 1991. A95-91479 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 47-58

Copyright

The computation of unsteady fluid flows around projectiles maneuvering with non uniform motion requires hugh amounts of operations, because of the large mesh size and of the great number of time steps necessary to get a sufficient time and space accuracy for the solution. For such problems, the design of high performance codes to be implemented on vector and parallel supercomputers is mandatory. In this paper, we present a complete numerical method for solving three dimensional unsteady Euler equations around missiles, and we analyze the results with the vector optimization and the parallel implementation on CRAY supercomputers of the derived code. In the first part, the mathematical model and the numerical solution scheme are introduced. This scheme is based upon a finite-volume space discretization and a second order time discretization, with an explicit LAX-WENDROFF step and an implicit residual smoothing step. A specific domain decomposition method is presented in the second part. The domain decomposition approach is required to allow the definition of complex geometries with locally structured mesh blocks. A particular method for coupling the subdomains is provided for the implicit phase of computation that preserves the stability of the scheme with low overcost. Furthermore, we describe the application of this approach to the parallel

computing mode. The third part of this paper deals with the vector optimization of the code, and gives performance results on CRAY-2 and CRAY-XMP, for various meshsizes. The last part is devoted to the presentation of results with the parallel implementation of the code on a real-world three dimensional case of missile performing pitching oscillations. The high performance obtained and the accuracy of the solution prove the efficiency of the implicit multidomain approach for solving these industrial problems.
Author (Herner)

A95-91487* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

AERODYNAMIC SIMULATION ON MASSIVELY PARALLEL SYSTEMS

JOCHEM HAEUSER European Space Research and Technology Centre, ESA, Noordwijk, Netherlands and HORST D. SIMON NASA. Ames Research Center, Moffett Field, CA, US *In* Parallel computational fluid dynamics '91; Conference Proceedings, Stuttgart, Germany, Jun. 10-12, 1991. A95-91479 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 207-225
Copyright

This paper briefly addresses the computational requirements for the analysis of complete configurations of aircraft and spacecraft currently under design to be used for advanced transportation in commercial applications as well as in space flight. The discussion clearly shows that massively parallel systems are the only alternative which is both cost effective and on the other hand can provide the necessary TeraFlops, needed to satisfy the narrow design margins of modern vehicles. It is assumed that the solution of the governing physical equations, i.e., the Navier-Stokes equations which may be complemented by chemistry and turbulence models, is done on multiblock grids. This technique is situated between the fully structured approach of classical boundary fitted grids and the fully unstructured tetrahedra grids. A fully structured grid best represents the flow physics, while the unstructured grid gives best geometrical flexibility. The multiblock grid employed is structured within a block, but completely unstructured on the block level. While a completely unstructured grid is not straightforward to parallelize, the above mentioned multiblock grid is inherently parallel, in particular for multiple instruction multiple datastream (MIMD) machines. In this paper guidelines are provided for setting up or modifying an existing sequential code so that a direct parallelization on a massively parallel system is possible. Results are presented for three parallel systems, namely the Intel hypercube, the Ncube hypercube, and the FPS 500 system. Some preliminary results for an 8K CM2 machine will also be mentioned. The code run is the two dimensional grid generation module of Grid, which is a general two dimensional and three dimensional grid generation code for complex geometries. A system of nonlinear Poisson equations is solved. This code is also a good testcase for complex fluid dynamics codes, since the same datastructures are used. All systems provided good speedups, but message passing MIMD systems seem to be best suited for large miltiblock applications.
Author (Herner)

A95-91490

SOLUTION OF THE NAVIER-STOKES EQUATIONS ON A MASSIVELY PARALLEL TRANSPUTER SYSTEM

E. ORTNER Technische Hochschule, Aachen, Germany, G. SEIDER Technische Hochschule, Aachen, Germany, and D. HAENEL Technische Hochschule, Aachen, Germany *In* Parallel computational fluid dynamics '91; Conference Proceedings, Stuttgart, Germany, Jun. 10-12, 1991. A95-91479 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 285-296
Copyright

Steady transonic flow around an airfoil is computed. For that purpose the Navier-Stokes equations are solved by a finite difference method using a high resolution upwind scheme. The time integration is done by an explicit five step Runge-Kutta method. The algebraic Baldwin-Lomax turbulence model is implemented to close the system of equations for turbulent flow. The original algorithm was developed and optimized for the use of vector computers. The present paper deals with the implementation and optimization of this code on a Parsytec SuperCluster-256, which is a message passing distributed memory system consisting of 265 T800 transputers. Parallelization of the algorithm is achieved by grid partitioning; a grid of 258 x 66 points is divided into slices and the data belonging to these overlapping subdomains is distributed on up to 128 transputer nodes. Computations are carried out for different numbers of transputers; speedup and efficiency of the code were measured. The results show that the processor and communication speed of the transputer system are in good balance for this Navier-Stokes solver. As the parallelized code runs without modifications and high efficiency on serial vector computers, the execution times can be compared.
Author (Herner)

A95-91682

THE AIR SYSTEMS CONTROLLERATE INITIATIVES AND POLICIES FOR THE PROCUREMENT OF RELIABLE AND MAINTAINABLE EQUIPMENT

D. W. DANIEL Ministry of Defence, UK and D. I. KNOWLES Ministry of Defence, UK 1991 4 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 6: Reliability)
(CONGRESS PAPER C428-6-113; HTN-95-21113) Copyright

This paper describes the need for greater emphasis on Reliability and Maintainability (R&M) in defense projects. It then discusses the procedures which have been introduced to establish and maintain accounability for the R&M requirements; the need to ensure that these requiremnts are operationally justified and economically feasible, and how compliance can be demonstrated.
Author (Herner)

A95-91683

THE IMPACT OF NEW TECHNOLOGY ON RELIABILITY OF AVIONIC EQUIPMENT

J. F. ROULSTON 1991 4 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 6: Reliability)
(CONGRESS PAPER C428-6-114; HTN-95-21114) Copyright

Future military avionic architecture will exploit new technology to provide greatly increased modularity with in both sensing and computing. The technology should realize improvements with respect to operational value of equipment while maintaining good economy. An underlying motivation for adoption of new technology is the possibility of distinguishing serial reliability and mission reliability. This paper describes likely architectural evolution and interprets the motivation for airline change. Examples are drawn from the typical sensor suite of a fighter aircraft and particular emphasis is given to new developments in electronically-scanned airborne radar.
Author (Herner)

A95-91684

THE AVIONICS INTEGRITY PROGRAMME (AVIP)

G. TAYLOR and B. RIGGALL 1991 10 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 6: Reliability)
(CONGRESS PAPER C428-6-115; HTN-95-21115) Copyright

The United States Air Force recognized the use of advanced avionic systems is a means of effectively improving aircraft performance and meeting the new operational challenges of the 21st century. However a potential conflict is emerging between the projected capabilities that avionics need to deliver (resulting in costly, complex systems), and the constraints that are being imposed (e.g., reduced cost, austere support environments). Therefore it is important that the design techniques employed result in equipment which will work satisfactorily for significant periods without maintenance and with minimal support cost. This will ensure that significant savings can be made in the cost of ownership which may make these systems affordable. This paper explains the Avionics Integrity Programmme (AVIP) approach to the problem.
Author (Herner)

A95-91726
NOVEL IMPLEMENTS OF OPTICAL DIAGNOSTIC TECHNIQUES FOR AEROSPACE APPLICATIONS
R. P. TATAM Cranfield Institute of Technology, UK, N. A. AHMED Cranfield Institute of Technology, UK, H. ATCHA Cranfield Institute of Technology, UK, C. J. DUFFY Cranfield Institute of Technology, UK, and R. L. ELDER Cranfield Institute of Technology, UK 1991 6 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 21: Propulsion 2 Diagnostics in Dev.)
(CONGRESS PAPER C428-21-081; HTN-95-21157) Copyright

The use of fiber optics instrumentation for aerospace applications is presented. The techniques discussed include a novel fiber optic three dimensional laser Doppler velocimeter for use in turbomachinery, the measurement of turbine blade vibration and surface contours using electronic speckle pattern interferometry, and the development of a fiber optic frequency shifter. Author (Herner)

A95-91915* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ALGORITHMIC TRENDS IN COMPUTATIONAL FLUID DYNAMICS; THE INSTITUTE FOR COMPUTER APPLICATIONS IN SCIENCE AND ENGINEERING (ICASE)/ LARC WORKSHOP, NASA LANGLEY RESEARCH CENTER, HAMPTON, VA, US, SEP. 15-17, 1991
M. Y. HUSSAINI, editor NASA. Langley Research Center, Hampton, VA, US, A. KUMAR, editor NASA. Langley Research Center, Hampton, VA, US, and M. D. SALAS, editor NASA. Langley Research Center, Hampton, VA, US New York, USA Springer-Verlag (ICASE/ NASA LaRC Series) 1993 423 p.
(ISBN 0-387-94014-6; HTN-95-12215) Copyright

The purpose here is to assess the state of the art in the areas of numerical analysis that are particularly relevant to computational fluid dynamics (CFD), to identify promising new developments in various areas of numerical analysis that will impact CFD, and to establish a long-term perspective focusing on opportunities and needs. Overviews are given of discretization schemes, computational fluid dynamics, algorithmic trends in CFD for aerospace flow field calculations, simulation of compressible viscous flow, and massively parallel computation. Also discussed are acceleration methods, spectral and high-order methods, multi-resolution and subcell resolution schemes, and inherently multidimensional schemes. For individual titles, see A95-91916 through A95-91927. Author (Herner)

A95-91916
A VIEWPOINT ON DISCRETIZATION SCHEMES FOR APPLIED AERODYNAMIC ALGORITHMS FOR COMPLEX CONFIGURATIONS
JOSEPH L. STEGER Univ. of California at Davis, Davis, CA, US *In* Algorithmic trends in computational fluid dynamics; The Institute for Computer Applications in Science and Engineering (ICASE)/LaRC Workshop, NASA Langley Research Center, Hampton, VA, US, Sep. 15-17, 1991. A95-91915 New York, USA Springer-Verlag (ICASE/NASA LaRC Series) 1993 p. 3-15 Research sponsored by the Air Force Wright Research and Development Center, Wright-Patterson Air Force Base
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In the 90's, nonlinear computational fluid dynamics (CFD) methods must begin to routinely simulate viscous unsteady flow of complete aircraft configurations. While the best approach for such simulations has yet to be determined, it is argued that the discretization requirements for unsteady viscous flow simulation of complex configurations will best be satisfied using either composite overset structured grids or a composite of prismatic and unstructured meshes - or a hybrid of these two. Author (Herner)

A95-91917
ALGORITHMIC TRENDS IN CFD IN THE 1990'S FOR AEROSPACE FLOW FIELD CALCULATIONS
ROBERT W. MACCORMACK Stanford Univ., Stanford, CA, US *In* Algorithmic trends in computational fluid dynamics; The Institute for Computer Applications in Science and Engineering (ICASE)/LaRC Workshop, NASA Langley Research Center, Hampton, VA, US, Sep. 15-17, 1991. A95-91915 New York, USA Springer-Verlag (ICASE/NASA LaRC Series) 1993 p. 21-32
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While the battles of the past concerning computational fluid dynamics (CFD) centered on shock fitting verses shock capturing algorithms or finite element verses finite difference procedures, present and future battles will be concerned with structured multi-block element grids verses unstructured single element grids, indirect relaxation or approximately factored procedures verses direct solution procedures, and turbulence modeling verses direct simulation of turbulent phenomena. These items are discussed with regard to the development of CFD for applications to aerospace problems of current and future engineering interest. It may appear premature to consider the item of direct simulation of turbulence as an alternative today. Indeed, it is with respect ot the prediction of turbulent flow past full aerospace configurations at flight conditions for the foreseeable future; but there are flows at considerably lower Reynolds numbers past elements of such configurations that could be conceivably attacked using this approach during the 1990's and the CFD community should perhaps be gearing up for it now. Author (revised by Herner)

A95-91925
BEYOND THE RIEMANN PROBLEM, PART 1
PHILIP L. ROE Univ. of Michigan, Ann Arbor, MI, US *In* Algorithmic trends in computational fluid dynamics; The Institute for Computer Applications in Science and Engineering (ICASE)/LaRC Workshop, NASA Langley Research Center, Hampton, VA, US, Sep. 15-17, 1991. A95-91915 New York, USA Springer-Verlag (ICASE/NASA LaRC Series) 1993 p. 341-367
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It is chiefly due to their reputation for reliability that upwind schemes have enjoyed such popularity during the past decade. In view of the remarks above one might expect this popularity to continue. However, there are some important classes of problem looming ahead for which the present upwind schemes, based on one-dimensional physical modelling, are not entirely satisfactory. These are largely to do with massively separated flow, turbulence, and mixing. The reasons for this will be reviewed below. I will then describe some of the attempts that have recently been made to devise improvements while still employing merely one-dimensional physical models. All of these methods have enjoyed enough success to suggest strongly that there is something 'out there' well work exploring. Very recently, though, we have come within sight of methods that preserve an even more intimate relationship between the numerical model and the physics of multidimensional flows. I will give a somewhat impressionistic overview of these. They resolve discontinuities over very small distances and without overshoots, despite containing no limiter functions or artificial viscosity, and they seem to have good convergence properties. Author (Herner)

N95-28719*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INFLUENCE OF TURBULENCE PARAMETERS, REYNOLDS NUMBER, AND BODY SHAPE ON STAGNATION-REGION HEAT TRANSFER
G. JAMES VANFOSSEN, ROBERT J. SIMONEAU, and CHAN Y. CHING (Syracuse Univ., NY.) Dec. 1994 48 p
(Contract(s)/Grant(s): RTOP 505-62-52)
(NASA-TP-3487; E-8882; NAS 1.60:3487) Avail: CASI HC A03/MF A01

The purpose of the present work was threefold: (1) to determine if a free-stream turbulence length scale existed that would cause the greatest augmentation in stagnation-region heat transfer over laminar levels; (2) to investigate the effect of velocity gradient on stagnation-region heat transfer augmentation by free-stream turbulence; and (3) to develop a prediction tool for stagnation heat transfer in the presence of free-stream turbulence. Heat transfer was measured in the stagnation region of four models with elliptical leading edges that had ratios of major to minor axes of 1:1, 1.5:1, 2.25:1, and 3:1. Five turbulence-generating grids were fabricated; four were square mesh, biplane grids made from square bars. The fifth grid was an array of fine parallel wires that were perpendicular to the model spanwise direction. Heat transfer data were taken at Reynolds numbers ranging from 37 000 to 228 000. Turbulence intensities were in the range of 1.1 to 15.9% while the ratio of integral length scale to leading-edge diameter ranged from 0.05 to 0.30. Stagnation-point velocity gradient was varied by nearly 50%. Stagnation-region heat transfer augmentation was found to increase with decreasing length scale but no optimum length scale was found. Heat transfer augmentation due to turbulence was found to be unaffected by the velocity gradient near the leading edge. A correlation was developed that fit heat transfer data for the square-bar grids to within +/- 4%. Author

N95-28725*# Lockheed Aeronautical Systems Co., Marietta, GA.
REQUIREMENTS FOR EFFECTIVE USE OF CFD IN AEROSPACE DESIGN
PRADEEP RAJ *In* NASA. Lewis Research Center, Surface Modeling, Grid Generation, and Related Issues in Computational Fluid Dynamic (CFD) Solutions p 15-28 Mar. 1995
Avail: CASI HC A03/MF A10

This paper presents a perspective on the requirements that Computational Fluid Dynamics (CFD) technology must meet for its effective use in aerospace design. General observations are made on current aerospace design practices and deficiencies are noted that must be rectified for the U.S. aerospace industry to maintain its leadership position in the global marketplace. In order to rectify deficiencies, industry is transitioning to an integrated product and process development (IPPD) environment and design processes are undergoing radical changes. The role of CFD in producing data that design teams need to support flight vehicle development is briefly discussed. An overview of the current state of the art in CFD is given to provide an assessment of strengths and weaknesses of the variety of methods currently available, or under development, to produce aerodynamic data. Effectiveness requirements are examined from a customer/supplier view point with design team as customer and CFD practitioner as supplier. Partnership between the design team and CFD team is identified as an essential requirement for effective use of CFD. Rapid turnaround, reliable accuracy, and affordability are offered as three key requirements that CFD community must address if CFD is to play its rightful role in supporting the IPPD design environment needed to produce high quality yet affordable designs. Derived from text

N95-28726*# General Electric Co., Schenectady, NY. Research and Development Center.
GRID GENERATION AND SURFACE MODELING FOR CFD
STUART D. CONNELL, JANET S. SOBER, and SCOTT H. LAMSON *In* NASA. Lewis Research Center, Surface Modeling, Grid Generation, and Related Issues in Computational Fluid Dynamic (CFD) Solutions p 29-43 Mar. 1995
Avail: CASI HC A03/MF A10

When computing the flow around complex three dimensional configurations, the generation of the mesh is the most time consuming part of any calculation. With some meshing technologies this can take of the order of a man month or more. The requirement for a number of design iterations coupled with ever decreasing time allocated for design leads to the need for a significant acceleration of this process. Of the two competing approaches, block-structured and unstructured, only the unstructured approach will allow fully automatic mesh generation directly from a CAD model. Using this approach coupled with the techniques described in this paper, it is possible to reduce the mesh generation time from man months to a few hours on a workstation. The desire to closely couple a CFD code with a design or optimization algorithm requires that the changes to the geometry be performed quickly and in a smooth manner. This need for smoothness necessitates the use of Bezier polynomials in place of the more usual NURBS or cubic splines. A two dimensional Bezier polynomial based design system is described. Author

N95-28732*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SURFACE MODELING AND GRID GENERATION FOR AEROPROPULSION CFD
YUNG K. CHOO, JOHN W. SLATER, JAMES LOELLBACH, and JINHO LEE (NYMA, Inc., Cleveland, OH.) *In its* Surface Modeling, Grid Generation, and Related Issues in Computational Fluid Dynamic (CFD) Solutions p 89-103 Mar. 1995
Avail: CASI HC A03/MF A10

The efforts in geometry modeling and grid generation at the NASA Lewis Research Center, as applied to the computational fluid dynamic (CFD) analysis of aeropropulsion systems, are presented. The efforts are mainly characterized by a focus on the analysis of components of an aeropropulsion system, which involve turbulent viscous flow with heat transfer and chemistry. Thus, this discussion will follow that characterization and will sequence through the components of typical propulsion systems consisting of inlets, compressors, combustors, turbines, and nozzles. For each component, some applications of CFD analysis will be presented to show how CFD is used to compute the desired performance information, how geometry modeling and grid generation are performed, and what issues have developed related to geometry modeling and grid generation. The discussion will illustrate the following needs related to geometry modeling and grid generation as observed in aeropropulsion analysis: (1) accurate and efficient resolution of turbulent viscous and chemically-reacting flowfields; (2) easy-to-use interfaces with CAD data for automated grid generation about complex geometries; and (3) automated batch grid generation software for use with design and optimization software.
Derived from text

N95-28736*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
BLOCK-STRUCTURED GRIDS FOR COMPLEX AERODYNAMIC CONFIGURATIONS: CURRENT STATUS
VEER N. VATSA, MARK D. SANETRIK (AS&M, Inc., Hampton, VA.), and EDWARD B. PARLETTE (Vigyan Research Associates, Inc., Hampton, VA.) *In* NASA. Lewis Research Center, Surface Modeling, Grid Generation, and Related Issues in Computational Fluid Dynamic (CFD) Solutions p 163-177 Mar. 1995
Avail: CASI HC A03/MF A10

The status of CFD methods based on the use of block-structured grids for analyzing viscous flows over complex configurations is examined. The objective of the present study is to make a realistic assessment of the usability of such grids for routine computations typically encountered in the aerospace industry. It is recognized at the very outset that the total turnaround time, from the moment the configuration is identified until the computational results have been obtained and postprocessed, is more important than just the computational time. Pertinent examples will be cited to demonstrate the feasibility of solving flow over practical configurations of current interest on block-structured grids. Derived from text

N95-28767*# National Aerospace Lab., Amsterdam (Netherlands).
DEMONSTRATION OF AN AUTOMATED CFD SYSTEM FOR THREE-DIMENSIONAL FLOW SIMULATIONS
J. W. VANDERBURG, J. E. J. MASELAND, R. HAGMEIJER, and K. M. J. DECOCK *In* NASA. Lewis Research Center, Surface Modeling, Grid Generation, and Related Issues in Computational Fluid Dynamic (CFD) Solutions p 713-730 Mar. 1995 Sponsored by Netherlands Agency for Aerospace Programs
Avail: CASI HC A03/MF A10

In this paper the capabilities of an automated CFD system which is currently available at NLR are demonstrated. Transonic flow around the AS28G wing/body configuration and hypersonic flow through a generic three-dimensional mixed-compression airbreathing inlet are simulated. An assessment of the level of automation of the current CFD-system is made. The problem-turnaround time lies within the order of a week for both applications. Author

N95-28768*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

A PROCEDURE FOR AUTOMATING CFD SIMULATIONS OF AN INLET-BLEED PROBLEM

WEI J. CHYU, MARK J. RIMLINGER (Carnegie-Mellon Univ., Pittsburgh, PA.), and TOM I.-P. SHIH (Carnegie-Mellon Univ., Pittsburgh, PA.) *In* NASA. Lewis Research Center, Surface Modeling, Grid Generation, and Related Issues in Computational Fluid Dynamic (CFD) Solutions p 731-749 Mar. 1995

Avail: CASI HC A03/MF A10

A procedure was developed to improve the turn-around time for computational fluid dynamics (CFD) simulations of an inlet-bleed problem involving oblique shock-wave/boundary-layer interactions on a flat plate with bleed into a plenum through one or more circular holes. This procedure is embodied in a preprocessor called AUTOMAT. With AUTOMAT, once data for the geometry and flow conditions have been specified (either interactively or via a namelist), it will automatically generate all input files needed to perform a three-dimensional Navier-Stokes simulation of the prescribed inlet-bleed problem by using the PEGASUS and OVERFLOW codes. The input files automatically generated by AUTOMAT include those for the grid system and those for the initial and boundary conditions. The grid systems automatically generated by AUTOMAT are multi-block structured grids of the overlapping type. Results obtained by using AUTOMAT are presented to illustrate its capability. Author

N95-28847*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

TECHNOLOGY INTEGRATION BOX BEAM FAILURE STUDY

M. J. SHUART, DAMODAR R. AMBUR, D. D. DAVIS, JR., R. C. DAVIS, G. L. FARLEY, C. G. LOTTS, and J. T. WANG *In its* Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 951-965 Jan. 1993

Avail: CASI HC A03/MF A04

Composite structures have the potential to be cost-effective, structurally efficient primary aircraft structures. The Advanced Composites Technology (ACT) Program has the goal to develop the technology to exploit this potential for heavily loaded aircraft structures. As part of the ACT Program, Lockheed Aeronautical Systems Company completed the design and fabrication of the Technology Integration Box Beam (TIBB). The TIBB is an advanced composite prototype structure for the center wing section of the C-130 aircraft. Lockheed subjected the TIBB to downbending, upbending, torsion and combined upbending and torsion load conditions to verify the design. The TIBB failed at 83 percent of design ultimate load for the combined upbending and torsion load condition. The objective of this paper is to describe the mechanisms that led to the failure of the TIBB. The results of a comprehensive analytical and experimental study are presented. Analytical results include strain and deflection results from both a global analysis of the TIBB and a local analysis of the failure region. These analytical results are validated by experimental results from the TIBB tests. The analytical and experimental results from the TIBB tests are used to determine a sequence of events that resulted in failure of the TIBB. A potential cause of failure is high stresses in a stiffener runout region. Analytical and experimental results are also presented for a stiffener runout specimen that was used to simulate the TIBB failure mechanisms.

Derived from text

N95-28848*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A GLOBAL/LOCAL ANALYSIS METHOD FOR TREATING DETAILS IN STRUCTURAL DESIGN

MOHAMMAD A. AMINPOUR (Analytical Services and Materials, Inc., Hampton, VA.), SUSAN L. MCCLEARY (Lockheed Engineering and Sciences Co., Hampton, VA.), and JONATHAN B. RANSOM *In its* Third NASA Advanced Composites Technology Conference, Volume 1, Part 2 p 967-986 Jan. 1993

(Contract(s)/Grant(s): NAS1-19317; NAS1-19000)

Avail: CASI HC A03/MF A04

A method for analyzing global/local behavior of plate and shell structures is described. In this approach, a detailed finite element model of the local region is incorporated within a coarser global finite element model. The local model need not be nodally compatible (i.e., need not have a one-to-one nodal correspondence) with the global model at their common boundary; therefore, the two models may be constructed independently. The nodal incompatibility of the models is accounted for by introducing appropriate constraint conditions into the potential energy in a hybrid variational formulation. The primary advantage of this method is that the need for transition modeling between global and local models is eliminated. Eliminating transition modeling has two benefits. First, modeling efforts are reduced since tedious and complex transitioning need not be performed. Second, errors due to the mesh distortion, often unavoidable in mesh transitioning, are minimized by avoiding distorted elements beyond what is needed to represent the geometry of the component. The method is applied reduced to a plate loaded in tension and transverse bending. The plate has a central hole, and various hole sixes and shapes are studied. The method is also applied to a composite laminated fuselage panel with a crack emanating from a window in the panel. While this method is applied herein to global/local problems, it is also applicable to the coupled analysis of independently modeled components as well as adaptive refinement. Author

N95-28903 ESDU International Ltd., London (England).

WAVE DRAG COEFFICIENT FOR AXISYMMETRIC FORECOWLS AT ZERO INCIDENCE (M SUB INFINITY LESS THAN OR EQUAL TO 1.5)

Jun. 1994 89 p

(ISSN 0141-4356)

(ESDU-94014; ISBN-0-85679-901-7) Avail: ESDU

ESDU 94014 presents charts for 20 cowls of the coefficient computed from finite difference solutions to the Euler equations for inviscid compressible flow. Computed shock waves are smeared over a few mesh cells which should give correct shock pressure jumps and wave drag. Data are presented for ranges of values of mass flow ratio and freestream Mach number. Sixteen cowls have NACA 1-series external profile, with differing combinations of diameter ratio and fineness ratio. The remaining four have fixed diameter ratio and fineness ratio but external profiles that differ systematically from the NACA 1-series profile. Charts of computed forecowl pressure force coefficient and pre-entry force coefficient are also given for each cowl for conditions at which a non-zero wave drag is calculated. See ESDU 94013 for details of the NACA 1-series profile and ESDU 94015 for pressure distribution data for the same profiles as treated here. Author

N95-28948 Air Force Inst. of Tech., Wright-Patterson AFB, OH.

A NONINTRUSIVE METHOD OF QUANTIFYING FLOW VISUALIZATION DATA IN VORTEX FLOW FIELDS M.S. Thesis

VINCENT J. SEI Dec. 1994 86 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality

(AD-A289802; AFIT/CI/CIA-94-170) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The High Angle of Attack Research Vehicle (HARV) as well as other similar flight test aircraft have been using smoke flow visualization techniques to characterize the vortex flow created by leading edge extensions and the forebody. With the advent of video measurement techniques, this type of flow visualization can not only provide a qualitative assessment of the flow but also a quantitative measure to be used to validate computational fluid dynamic codes and wind tunnel test. One of the major drawbacks to employing video imaging was the introduction of false motion due to camera movement in flight. A relative motion approach using fixed targets along with the flow visualization scheme was utilized to remove unwanted motion. The relative motion algorithm was tested using a laboratory test setup where cameras underwent both translational and rotational motion to simulate both wing bending and torsion. The method was effective in removing both motions with only a slight loss of accuracy. DTIC

N95-29060# Arizona State Univ., Tempe, AZ.
EXPERIMENTAL AND THEORETICAL STUDIES OF WAKES IN STRATIFIED FLOWS Final Report
DON L. BOYER and H. J. FERNANDO 20 Jan. 1995 6 p
(Contract(s)/Grant(s): N00014-90-J-4063)
(AD-A290203) Avail: CASI HC A02/MF A01

The long range goal was to obtain, by laboratory experimentation and associated theoretical/numerical analysis, an increased understanding of the dynamics of stratified flow past blunt obstacles including two-dimensional ones such as right circular cylinders and three-dimensional ones such as spheres. Emphasis was given to such phenomena as blocking, flow separation, vortex shedding, lee-wave generation, unsteady characteristics of the free stream, and lift and drag on the obstacles in question. DTIC

N95-29112*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INFLUENCE OF TOOTH PROFILE MODIFICATION ON SPUR GEAR DYNAMIC TOOTH STRAIN
FRED B. OSWALD and DENNIS P. TOWNSEND Jun. 1995 11 p
Presented at the 31st Joint Propulsion Conference and Exhibit, San Diego, CA, 10-12 Jul. 1995; sponsored by AIAA, ASME, SAE, and ASEE
(Contract(s)/Grant(s): RTOP 505-62-36; DA PROJ. 1L1-62211-A-47-A)
(NASA-TM-106952; E-9691; NAS 1.15:106952; ARL-TR-778; AIAA PAPER 95-3050) Avail: CASI HC A03/MF A01

This paper presents results of dynamic strain gage measurements performed on the NASA gear-noise rig. The experiments were part of a joint research program between NASA and the U.S. Army Research Laboratory to advance the technology of rotorcraft transmissions. Tests were performed on six sets of low contact ratio spur gears with different tooth profile modifications. Results presented include static and dynamic measurements of gear tooth strain taken over a matrix of operating conditions. The results demonstrate that a well-designed tooth profile modification can significantly reduce dynamic loads in spur gears, especially for gears which operate at high speed and under high torque. The two parabolic modifications tested were not as effective as linear modifications, possibly because the modification zone was too long. Author

N95-29119 Concordia Univ., Montreal (Quebec).
FINITE ELEMENT VORTICITY-BASED METHODS FOR THE SOLUTION OF THE INCOMPRESSIBLE AND COMPRESSIBLE NAVIER-STOKES EQUATIONS Ph.D. Thesis
GRANT GUEVREMONT 1993 178 p
Avail: Univ. Microfilms Order No. DANN87265

Finite element vorticity-based methods are applied to the analysis of viscous flows. This is carried out in terms of a stream function-vorticity formulation for 2-D flows and a velocity-vorticity formulation for 2-D and 3-D flows. Second order equations are obtained for the variables and the discretization is based on the weak-Galerkin weighted residual method. The stream function-vorticity approach proposed in this thesis reverses the traditional imposition of wall boundary conditions. The finite element method is used to naturally impose the no-slip condition on the stream function equation accurate for complex geometries. This method is extended to two-dimensional subsonic external lifting flow. The unknown stream function value on the airfoil, for lifting flow, is obtained by enforcing a continuous pressure distribution over the entire airfoil. This is imposed naturally through the finite element discretized vorticity transport equation. The velocity-vorticity scheme proposed in this thesis was the first to use a finite element weak-Galerkin method. This method is extended beyond incompressible flow to two- and three-dimensional subsonic internal flow. A new accurate wall vorticity boundary condition is also proposed. The finite element is chosen to have equal order interpolation for the virtuosity and the first derivatives of velocity. The stream function and virtuosity or the velocity and virtuosity are solved simultaneously using a Newton method. At each iteration, the linear algebraic system is solved by either a direct or an iterative matrix solver. For subsonic flows, the iteration is completed by obtaining the pressure, temperature, density and viscosity. Although it was found necessary in some cases to obtain solutions at intermediary Reynolds numbers, no artificial viscosity was required to stabilize the iteration algorithm. The schemes demonstrate the advantages of the finite element method in providing natural boundary conditions for such problems. Dissert. Abstr.

N95-29187# Wright Lab., Wright-Patterson AFB, OH.
COMPUTATIONAL FLUID DYNAMICS (CFD) ANALYSIS OF A C-135 AIRCRAFT WITH A SIDE-MOUNTED SPLITTER PLATE (WITH COMPARISON TO WIND TUNNEL DATA) Final Report, Mar. - Jun. 1993
HOWARD T. EMSLEY Jun. 1994 114 p
(Contract(s)/Grant(s): AF PROJ. 2404)
(AD-A292029; WL-TR-94-3089) Avail: CASI HC A06/MF A02

A Computational Fluid Dynamics (CFD) analysis was performed on a C-135 aircraft with a side-mounted splitter plate at the request of the Airborne Laser SPO at Kirtland AFB, and the 4950 Test Wing at Wright-Patterson AFB. The data collected from the analysis was provided to the Test Wing to augment wind tunnel tests and to provide loading and stability information on the modified aircraft. This work was a precursor to a planned flight test program in which a splitter plate will be tested on a Test Wing aircraft. Four flight conditions were analyzed with a modified and unmodified C-135 aerodynamic model, and incremental stability and aerodynamic derivatives were determined. Additionally, pressure coefficient data were tabulated for use in a structural analysis by the Test Wing. DTIC

N95-29197 Stanford Univ., CA.
SOLUTION OF THE NAVIER-STOKES EQUATIONS ON LOCALLY REFINED CARTESIAN MESHES USING STATE-VECTOR SPLITTING Ph.D. Thesis
CARL FREDERICK GOOCH 1994 162 p
Avail: Univ. Microfilms Order No. DA9414570

A large amount of user time and expertise is currently required to obtain accurate computational solutions to compressible flow problems, especially if the geometry or flow field is complex. This presents a barrier for the novice user and an inconvenience for the experienced user. This thesis explores several options for improving this situation. First, grid-independent solution schemes would relax the current astringent criteria on grid quality. Recent developments in the area of multi-dimensional upwind schemes show promise for reducing grid dependence significantly. In the present work, a multi-dimensional upwind scheme for the Euler equations has been extended in a natural way to solve the Navier-Stokes equations. This approach treats the viscous and inviscid terms together. Second, automatic grid generation would drastically reduce the amount of work required to obtain a solution — of any quality — for complex geometries. Grid generation for complex, multi-body geometries is presently a formidable task, especially for structured grids. If non-body-fitted Cartesian grids are used, however, grid generation becomes trivial. The primary difficulty in using non-body-fitted grids is the enforcement of the solid wall boundary condition. The present work uses Cartesian grids in conjunction with a boundary condition similar to the usual finite volume boundary condition. Finally, an automatic grid refinement scheme with the capability to produce and recognize a grid-converged solution would obviate the grid refinement studies currently required to ensure the accuracy of a solution. A refinement scheme has been developed which adds cells based on a measure of the local error in the steady-state solution rather than on derivatives of some flow variable. As such, the scheme can in principle continue to refine until the local error in the solution is everywhere less than some user-specified quantity. The Navier-Stokes solver and the new Cartesian mesh boundary conditions have been validated. Comparison has been made to several cases for which analytic solutions are known. Inviscid subsonic flow around a biplane configuration was calculated to demonstrate the generality of the grid generation and local refinement schemes. A separated laminar airfoil flow has also been calculated, in conjunction with the automatic grid refinement scheme. Dissert. Abstr.

N95-29228# Texas Univ., Austin, TX.
UNSTEADINESS OF SHOCK-INDUCED TURBULENT BOUNDARY LAYER SEPARATION. AN INHERENT FEATURE OF TURBULENT FLOW OR SOLELY A WIND TUNNEL PHENOMENON Final Report
D. S. DOLLING and M. E. ERENGIL Aug. 1994 55 p
(Contract(s)/Grant(s): DAAL03-91-G-0023)
(AD-A290367; ARO-28293.4-EG) Avail: CASI HC A04/MF A01

The purpose of this work was to: (1) examine separation shock wave unsteadiness in different turbulent interactions and determine whether a universal model describing the unsteadiness could be developed, and (2) determine whether or not the observed unsteadiness is a feature of turbulent flow in general, or is specific to the wind tunnel environment. To this end, wall and pitot pressure fluctuation measurements were made in interactions generated by unswept and 25 deg swept compression ramp models, and by 8 deg and 30 deg swept blunt-fin models in a high Reynolds number, Mach 5 turbulent boundary layer. It is clear that the high-frequency, jittery motion of the separation shock is the result of the passage through the wave of individual large-scale turbulent structures. Thus, this component of the unsteadiness is an inherent feature of all turbulent flows. The primary outstanding question concerns the cause of the low-frequency expansion/contraction of the separated flow which is characterized by the large-scale, long-duration excursions of the separation shock wave. Preliminary experimental work to address this question has revealed two very interesting, complementary results. First, there is a distinct correlation between large-scale expansion or contraction of the separated flow and long duration (i.e., low-frequency) falls or rises in pitot pressure in the incoming turbulent boundary layer. Second, results from the same experiment show that the ensemble-averaged pitot pressure at a fixed location in the incoming undisturbed boundary layer correlates with separation shock wave position. DTIC

N95-29242 Georgia Inst. of Tech., Atlanta, GA.
A FOURTH ORDER EULER/NAVIER-STOKES PREDICTION METHOD FOR THE AERODYNAMICS AND AEROELASTICITY OF HOVERING ROTOR BLADES Ph.D. Thesis
MARILYN JONES SMITH 1994 226 p
Avail: Univ. Microfilms Order No. DA9421065

Some of the computational issues relating to the development of a three-dimensional fourth-order compact Euler/Navier-Stokes methodology for rotary wing flows and its coupling with an elastic rotor blade beam structural model have been explored. The compact Euler/NavierStokes method is used to predict the aerodynamic loads on an isolated rotor blade. Because the scheme is fourth-order, fewer grid nodes are necessary to predict loads with the same accuracy as traditional second order methodologies on finer grids. Grid and numerical parameter optimizations were performed to examine the changes in the predictive capabilities of the higher-order scheme. Comparisons were made with experimental data for a rotor using NACA 0012 airfoil sections and a rectangular planform with no twist. Simulations for both lifting and non-lifting configurations at various tip Mach numbers were performed. This Euler/Navier-Stokes methodology can be applied to rotor blades with either rigid-blade or elastic-beam-structural models to determine the steady-state response in hovering flight. The blade is represented by a geometrically nonlinear beam model which accounts for coupled flap bending, lead-lag bending and torsion. Moderately large displacements and rotations due to structural deformations can be simulated. The analysis has been performed for blade configurations having uniform mass and stiffness, no twist, and no chordwise offsets of the elastic and tension axes, as well as the center of mass. The results are compared with a panel method coupled with the same structural dynamics model. Computations have been made to predict the aerodynamic deflections for the rotor in hover. A starting solution using initial deflections predicted by aeroelastic analyses with a two-dimensional aerodynamic model was investigated. The present Euler/Navier-Stokes method using a momentum wake and a contracting vortex wake shows the impact on the aeroelastic deflections of a three-dimensional aerodynamic module which includes rotational and viscous effects, particularly at higher collective pitch angles. The differences in the aeroelastic predictions using fully coupled and loosely coupled aerodynamic analyses are examined. The induced wake plays a critical role in determining the final equilibrium tip deflections. Dissert. Abstr.

N95-29371*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
GRID ORTHOGONALITY EFFECTS ON PREDICTED TURBINE MIDSPAN HEAT TRANSFER AND PERFORMANCE
R. J. BOYLE and A. A. AMERI (Kansas Univ., Lawrence, KS.) Jun. 1995 13 p Presented at the 39th International Gas Turbine and Aeroengine Congress and Exposition, The Hague, NL, 13-16 Jun. 1994; sponsored by ASME
(Contract(s)/Grant(s): RTOP 505-62-52)
(NASA-TM-106931; E-9652; NAS 1.15:106931) Avail: CASI HC A03/MF A01

The effect of five different C type grid geometries on the predicted heat transfer and aerodynamic performance of a turbine stator is examined. Predictions were obtained using two flow analysis codes. One was a finite difference analysis, and the other was a finite volume analysis. Differences among the grids in terms of heat transfer and overall performance were small. The most significant difference among the five grids occurred in the prediction of pitchwise variation in total pressure. There was consistency between results obtained with each of the flow analysis codes when the same grid was used. A grid generating procedure in which the viscous grid is embedded within an inviscid type grid resulted in the best overall performance. Author

N95-29387# Hampton Univ., VA.
DEVELOPMENT OF A ROTARY WING NAVIER-STOKES CFD CODE BASED ON TLNS3D CODE Final Report, 30 Sep. 1992 - 31 Aug. 1994
HONG HU Sep. 1994 38 p
(Contract(s)/Grant(s): DAAL03-92-G-0416)
(AD-A290421; ARO-30697.1-EG-H) Avail: CASI HC A03/MF A01

This report documents the development of a multi-grid Navier-Stokes code for rotary wing calculations, TLNS3DR. The TLNS3DR is based on the fixed-wing TLNS3D code by adding a rotation term and making necessary modifications on boundary conditions. The TLNS3D code solves the thin-layer Navier-Stokes equations using an explicit multistage Runge-Kutta type of time stepping with multigrid method. The TLNS3DR code reformulates the TLNS3D code in the rotor blade-fixed moving frame of reference and solves relative motion of fluids. In this report, the formulation of the Navier-Stokes equations in the moving frame of reference in terms of relative velocity is given. Several numerical examples are then presented. The results of rotor blade in hover calculated by the new TLNS3DR code seems quantitatively correct. The computation also shows that this multigrid code is efficient. DTIC

N95-29453*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A HYBRID ELECTRONICALLY SCANNED PRESSURE MODULE FOR CRYOGENIC ENVIRONMENTS
J. J. CHAPMAN, P. HOPSON, JR., and N. KRUSE May 1995 12 p
(Contract(s)/Grant(s): RTOP 505-59-54-02)
(NASA-TM-110146; NAS 1.15:110146) Avail: CASI HC A03/MF A01

Pressure is one of the most important parameters measured when testing models in wind tunnels. For models tested in the cryogenic environment of the National Transonic Facility at NASA Langley Research Center, the technique of utilizing commercially available multichannel pressure modules inside the models is difficult due to the small internal volume of the models and the requirement of keeping the pressure transducer modules within an acceptable temperature range well above the -173 degrees C tunnel temperature. A prototype multichannel pressure transducer module has been designed and fabricated with stable, repeatable sensors and materials optimized for reliable performance in the cryogenic environment. The module has 16 single crystal silicon piezoresistive pressure sensors electrostatically bonded to a metalized Pyrex substrate for sensing the wind tunnel model pressures. An integral temperature sensor mounted on each silicon micromachined pressure sensor senses real-time temperature fluctuations to within 0.1 degrees C to correct for thermally induced non-random sensor drift. The data presented here are from a prototype sensor module tested in the 0.3 M cryogenic tunnel and thermal equilibrium conditions in an environmental chamber which approximates the thermal environment (-173 degrees C to +60 degrees C) of the National Transonic Facility. Author

N95-29538*# Textron Bell Helicopter, Fort Worth, TX.
BELL HELICOPTER ADVANCED ROTOCRAFT TRANSMISSION (ART) PROGRAM Final Report
ZACHARY S. HENRY Jun. 1995 221 p
(Contract(s)/Grant(s): NAS3-25455; RTOP 505-62-36; DA PROJ. 1L1-6221-A-47-A)
(NASA-CR-195479; E-9708; NAS 1.26:195479; ARL-CR-238) Avail: CASI HC A10/MF A03

Future rotorcraft transmissions require key emerging material and component technologies using advanced and innovative design practices in order to meet the requirements for a reduced weight to power ratio, a decreased noise level, and a substantially increased reliability. The specific goals for the future rotorcraft transmission when compared with a current state-of-the-art transmission (SOAT) are: (1) a 25 percent weight reduction; (2) a 10 dB reduction in the transmitted noise level; and (3) a system reliability of 5000 hours mean-time-between-removal (MTBR) for the transmission. This report summarizes the work conducted by Bell Helicopter Textron, Inc. to achieve these goals under the Advanced Rotorcraft Transmission (ART) program from 1988 to 1995. The reference aircraft selected by BHTI for the ART program was the Tactical Tiltrotor which is a 17,000 lb gross weight aircraft. A tradeoff study was conducted comparing the ART with a Selected SOAT. The results showed the ART to be 29 percent lighter and up to 13 dB quieter with a calculated MTBR in excess of 5000 hours. The results of the following high risk component and material tests are also presented: (1) sequential meshing high contact ratio planetary with cantilevered support posts; (2) thin dense chrome plated M50 NiL double row spherical roller planetary bearings; (3) reduced kinematic error and increased bending strength spiral bevel gears; (4) high temperature WE43 magnesium housing evaluation and coupon corrosion tests; (5) flexure fatigue tests of precision forged coupons simulating precision forged gear teeth; and (6) flexure fatigue tests of plasma carburized coupons simulating plasma carburized gear teeth. Author

N95-29562# Virginia Univ., Charlottesville, VA. School of Engineering and Applied Science.
SEVERE EDGE EFFECTS AND SIMPLE COMPLIMENTARY INTERIOR SOLUTIONS FOR THIN-WALLED ANISOTROPIC AND COMPOSITE STRUCTURES Final Report, 1 Jan. 1991 - 31 Dec. 1994
C. O. HORGAN and J. G. SIMMONDS 31 Dec. 1994 16 p
(Contract(s)/Grant(s): DAAL03-91-G-0022)
(AD-A290645; ARO-28399.15-EG) Avail: CASI HC A03/MF A01

Many useful thin-walled structures of interest to the U.S. Army, such as rifle barrels, automotive parts, rocket casings, helicopter blades, driveshafts, and containment vessels, are often constructed of layers of anisotropic, filament or fiber-reinforced materials. While many of these structures are subject to severe mechanical, inertial, or thermal loads, they often must be designed to remain elastic. This means that it is particularly important to be able to compute accurately global characteristics, such as buckling loads and natural frequencies, as well as local information such as stresses near holes or edges. Two important, complementary regions of such structures, have been studied, namely, the interior where there are no steep stress gradients, and the edge zone(s) where stress gradients are high. For both regions, simplified, cost-effective asymptotic methods have been developed. These considerations are particularly important in layered, anisotropic structures because many investigators have (1) claimed that higher-order (and hence computationally expensive) beam, plate, or shell theories are needed for such structures and (2) not paid sufficient attention to the particularly severe end effects (breakdown of Saint-Venant's principle) such structures engender. DTIC

N95-29654# Imperial Coll. of Science and Technology, London (England).
THE EFFECTS OF THREE DIMENSIONAL IMPOSED DISTURBANCES ON BLUFF BODY NEAR WAKE FLOWS
NICHOLAS TOMBAZIS and PETER BEARMAN Apr. 1994 208 p
(Contract(s)/Grant(s): N00014-90-J-4083)
(AD-A290824) Avail: CASI HC A10/MF A03

The three-dimensionality of the near wake of bluff bodies at high Reynolds numbers is studied experimentally. Measurements were carried out in a 0.91 m x 0.91m wind tunnel (for Re =20000 to 60000) and flow visualisation in a 0.6m x 0.6m water flume (for Re=2500). The main purpose is to identify inherent three-dimensional features that may also arise in nominally two-dimensional flows. In order to fix the three-dimensional effects in both time and space, a mild, periodic, geometrical disturbance was imposed on the otherwise two-dimensional geometry of a model with a blunt trailing edge. The trailing edge thus followed a sinusoidal pattern, but a straight edge model was also studied for comparison purposes. Quantitative measurements and flow visualisation revealed that a dual shedding frequency characteristic prevails in the wake of the sinusoidal model. Base drag shows a noticeable drop (in comparison to the straight edge model). Most of the activity seems to happen in the region of the peak, where the dual frequency characteristic is more apparent and also the base drag shows its largest variations. Flow visualisation showed different modes of vortex shedding to exist. Vortical structures in the x- and z- directions were observed for both models. WZ vortices are present in the near wake. It is believed that the observed vortices are responsible for the intense base pressure fluctuations and gradients, and also for thin 'wisps' appearing between Karman' vortices in flow visualisation. DTIC

N95-29712# Tokyo Univ. (Japan). Inst. of Space and Astronautical Science.
EXPERIMENTAL STUDIES ON BOUNDARY-LAYER TRANSITION ON A REENTRY VEHICLE AT TRANSONIC AND SUPERSONIC SPEEDS
KOJIRO SUZUKI and TAKASHI ABE Mar. 1995 20 p
(ISAS-659) Avail: CASI HC A03/MF A01

The boundary-layer transition on the EXPRESS reentry capsule at transonic and supersonic speeds is studied experimentally by the wind tunnel tests. For the diagnostic of the turbulent transition of the boundary layer, the China-clay method is used. The experimental results clarify that when the freestream Mach number increases, the transition point moves downstream on the body surface and the distance between the beginning of the transition and its completion to the fully turbulent flow becomes larger. The effects of the freestream Mach number on the location of the boundary-layer transition are described successfully in terms of two nondimensional quantities, that is, the transition Reynolds number and the local Mach number at the boundary-layer edge. The oil-flow pictures reveal that in the transonic regime, the separation bubble is formed at the junction between the blunt nose and the conical part of the body and therefore the transition begins behind the reattachment point of the separation bubble. The effects of the turbulent transition on the aerodynamic characteristics of the reentry body are investigated by using the technique of the boundary-layer trip and the experimental results show that the aerodynamic characteristics of the EXPRESS reentry vehicle are not sensitive to the boundary-layer transition. Author

N95-29729 Clemson Univ., SC.
EFFECTS OF ELEVATED FREE-STREAM TURBULENCE AND STREAMWISE ACCELERATION ON FLOW AND THERMAL STRUCTURES IN TRANSITIONAL BOUNDARY LAYERS Ph.D. Thesis
DADONG ZHOU 1993 339 p
Avail: Univ. Microfilms Order No. DA9419670

The effects of elevated free-stream turbulence and streamwise accelerations on flow and thermal structures in transitional boundary layers were investigated experimentally on a heated flat plate with elevated free-stream turbulence (FSTI) levels ranged from 3 to 7 percent, and the acceleration strength, based on K (defined as (nu/U sub infinity squared) dU sub infinity/dx), ranged from 0.39 x 10(exp -6) to 4.1 x 10(exp -6). A case with low FSTI at 0.5 percent without streamwise acceleration was used as the baseline case for comparison. A miniature three-wire probe was used to measure detailed momentum and thermal boundary layer structures, including the streamwise and cross-steam velocity fluctuations, temperature fluctuations, Reynolds stresses, Reynolds heat fluxes, eddy viscosity, turbulent thermal diffusivity, and turbulent Prandtl numbers. Wall heat transfer measurements were made on the heated test wall. Onset and end of transition were inferred from the Stanton number distributions. A conditional sampling technique was utilized to separate the flow into the turbulent and nonturbulent portions. An analysis of flow and thermal structures was performed in each portion separately. Spectral analyses for turbulent energy and thermal energy were performed. Dissert. Abstr.

N95-29807 Wisconsin Univ., Madison, WI.
AIR/FUEL RATIO VISUALIZATION IN A DIESEL SPRAY Ph.D. Thesis
KEVIN DAVID CARABELL 1993 258 p
Avail: Univ. Microfilms Order No. DA9410596

To investigate some features of high pressure diesel spray ignition, we have applied a newly developed planar imaging system to a spray in an engine-fed combustion bomb. The bomb is designed to give flow characteristics similar to those in a direct injection diesel engine yet provide nearly unlimited optical access. A high pressure electronic unit injector system with on-line manually adjustable main and pilot injection features was used. The primary scalar of interest was the local air/fuel ratio, particularly near the spray plumes. To make this measurement quantitative, we have developed a calibration LIF technique. The development of this technique is the key contribution of this dissertation. The air/fuel ratio measurement was made using biacetyl as a seed in the air inlet to the engine. When probed by a tripled Nd:YAG laser the biacetyl fluoresces, with a signal proportional to the local biacetyl concentration. This feature of biacetyl enables the fluorescent signal to be used as as indicator of local fuel vapor concentration. The biacetyl partial pressure was carefully controlled, enabling estimates of the local concentration of air and the approximate local stoichiometry in the fuel spray. The results indicate that the image quality generated with this method is sufficient for generating air/fuel ratio contours. The processes during the ignition delay have a marked effect on ignition and the subsequent burn. These processes, vaporization and pre-flame kinetics, very much depend on the mixing of the air and fuel. This study has shown that poor mixing and over-mixing of the air and fuel will directly affect the type of ignition. An optimal mixing arrangement exists and depends on the swirl ratio in the engine, the number of holes in the fuel injector and the distribution of fuel into a pilot and main injection. If a short delay and a diffusion burn is desired, the best mixing parameters among those surveyed would be a high swirl ratio, a 4-hole nozzle and a small pilot. This arrangement provided the best combination of short ignition delay and diffusion burn for the majority of cases. Dissert. Abstr.

N95-29941# Conductus, Inc., Sunnyvale, CA.
THE MM-WAVE RESONANT METHODS FOR THE DETECTION OF CORROSION, PHASE 1 Final Report, 15 Jun. - 14 Dec. 1994
J. MARTENS and S. SACHTJEN 10 Feb. 1995 38 p
(Contract(s)/Grant(s): F49620-94-C-0049)
(AD-A291315; REPT-95-C-SRA-001; AFOSR-95-0099TR) Avail: CASI HC A03/MF A01

In this program, a class of mm-wave resonant tools known as surface resistance analyzers were evaluated for their ability to detect corrosion and extract information on corrosion products. The study was performed primarily on aluminum alloys exposed to salt fog conditions although a high temperature material sand steel alloys were also measured. The results on detection were uniformly encouraging. Statistically significant deviations in surface resistance were reported prior to visible corrosion products appearing. Incipient stress-related cracks around rivet holes were also detected on length scales of 0.1 mm. Complex permittivity data was extracted for the corrosion products and was used to estimated thicknesses, impurity levels, and composition changes during different exposure conditions. Incipient corrosion was also detected underneath several varieties of paint. The results suggest that this may be a useful measurement tool for the detection and analysis of corrosion in an aircraft maintenance environment. DTIC

N95-29946# Eltron Research, Inc., Boulder, CO.
ELECTROCHEMICAL IMPEDANCE PATTERN RECOGNITION FOR DETECTION OF HIDDEN CHEMICAL CORROSION ON AIRCRAFT COMPONENTS, PHASE 1 Final Report, 15 Jun. - 15 Dec. 1994
A. F. SAMMELLS and J. S. BOWERS 8 Feb. 1995 87 p
(Contract(s)/Grant(s): F49620-94-C-0043)
(AD-A291345; AFOSR-95-0106TR) Avail: CASI HC A05/MF A01

This investigation addressed the need for diagnostic instrumentation compatible with performing the Nondestructive Evaluation (NDE) of hidden chemical corrosion with a high degree of accuracy, sensitivity and versatility on both titanium and aluminum alloys currently used in Air Force and commercial aircraft. The overall approach was directed towards development of pattern recognition schemes based upon the on-line data acquisition of Fast Fourier Transform Electrochemical Impedance Spectroscopy (FFTEIS) instrumentation from the suspect hidden chemical corrosion site. Resulting impedance patterns were then analyzed by application of a Neural Network pattern recognition scheme. The Neural Network Analysis (NNA) was then trained to both detect and grade the severity of hidden corrosion present on the aircraft metal substrate interface of interest. Nueral Net Analysis of FFTEIS data was verified as a powerful diagnostic strategy for in situ hidden corrosion process identification, quantitative analysis and severity grading. Correlations between impedance measurements and corrosion depth were verified by subsequent SEM and EDX examination of the metal interfacial regions. The approach will also be powerful for gaining fundamental information into the nature of corrosion processes and conditions leading to their inception at hidden sites. DTIC

N95-30072# Federal Aviation Administration, Atlantic City, NJ.
OFFSHORE NEXT GENERATION WEATHER RADAR (NEXRAD) TEST AND EVALUATION MASTER PLAN (TEMP)
RADAME MARTINEZ, ROBERT CRANSTON, and JOHN PORCELLO Jan. 1995 49 p
(AD-A291435; DOT/FAA/CT-TN94/48) Avail: CASI HC A03/MF A01

This document provides the test philosophy and approach for the Offshore Next Generation Weather Radar (NEXRAD) Test and Evaluation Master Plan (TEMP). The NEXRAD differs from the typical Federal Aviation Administration (FAA) weather radar acquisition in that it is jointly funded by the Department of Defense (DOD), the Department of Commerce (DOC), and the Department of Transportation (DOT). These three agencies chartered the Joint System

Program Office (JSPO) to manage the NEXRAD development and subsequent test programs. JSPO has deployed 70 single-channel radar systems across the continental United States (CONUS). The FAA is deploying NEXRAD systems at non-CONUS (offshore) locations such as Alaska, Hawaii, and the Caribbean. The FAA Offshore NEXRAD will have a redundant configuration and a Remote Monitoring Subsystem (EMS). A total of 14 Offshore NEXRAD's will be procured under this acquisition: 3 in the Caribbean, 4 in Hawaii, and 7 in Alaska. Funding constraints will limit the acquisition to seven NEXRAD's in the 1994-1995 timeframe. DTIC

N95-30087# Wright Lab., Wright-Patterson AFB, OH.
SURVEY OF CFD APPLICATIONS FOR HIGH SPEED INLETS Final Report, Aug. 1992 - Jul. 1994
KEITH E. NUMBERS Jul. 1994 60 p
(Contract(s)/Grant(s): AF PROJ. 2404)
(AD-A291365; WL-TR-94-3131) Avail: CASI HC A04/MF A01

A comprehensive review of techniques and methods for applying computational fluid dynamics (CFD) analysis to high speed inlets and related flows is provided via an extensive literature survey of such applications. Topics covered include: governing equations, numerical integration schemes, boundary conditions, gridding requirements, and turbulence models. Results of applications from the literature survey shed light on the relative success of the techniques being used throughout the industry. DTIC

N95-30122# Naval Surface Warfare Center, Bethesda, MD.
175HP CONTRAROTATING HOMOPOLAR MOTOR DESIGN REPORT
MICHAEL J. CANNELL, JOHN L. DRAKE, RICHARD A. MCCONNELL, and WILLIAM R. MARTINO Jun. 1994 143 p
(AD-A291138; CARDIVNSWC-TR-81-94/25) Avail: CASI HC A07/MF A01

A normally conducting contrarotating homopolar motor has been designed and constructed. The reaction torque, in the outer rotor, from the inner rotor is utilized to produce true contrarotation. The machine utilizes liquid cooled conductors, high performance liquid metal current collectors, and ferrous conductors in the active region. The basic machine output is 175 hp at + or - 1,200 rpm with an input of 4 volts and 35,000 amps. DTIC

N95-30161*# Notre Dame Univ., IN.
THE PRESSURE FIELD OF A GUST INTERACTING WITH A FLAT PLATE
HAFIZ M. ATASSI and SHERYL M. PATRICK *In* NASA. Langley Research Center, ICASE/LaRC Workshop on Benchmark Problems in Computational Aeroacoustics (CAA) p 291-296 May 1995
Avail: CASI HC A02/MF A04

A semianalytical solution is presented for the unsteady pressure field of a vortical gust interacting with a flat-plate airfoil in subsonic flow. The solution will serve as a benchmark for evaluating the accuracy and efficiency of time dependent numerical schemes. The specific case considered corresponds to the ICASE benchmark problem number 6. The results are compared with those of asymptotic theories for high frequency and show excellent agreement. Author

N95-30224*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
BOUNDARY-LAYER TRANSITION AND GLOBAL SKIN FRICTION MEASUREMENT WITH AN OIL-FRINGE IMAGING TECHNIQUE
DARYL J. MONSON, GEORGE G. MATEER, and FLORIAN R. MENTER 1993 15 p
(NASA-CR-198814; NAS 1.26:198814) Avail: CASI HC A03/MF A01

A new oil-fringe imaging system skin friction (FISF) technique to measure skin friction on wind tunnel models is presented. In the method used to demonstrate the technique, lines of oil are applied on surfaces that connect the intended sets of measurement points, and then a wind tunnel is run so that the oil thins and forms interference fringes that are spaced in proportion to local skin friction. After a run the fringe spacings are imaged with a CCD-array digital camera and measured on a computer. Skin friction and transition measurements on a two-dimensional wing are presented and compared with computational predictions. Author

N95-30290 Iowa State Univ. of Science and Technology, Ames, IA.
AN INTERACTING BOUNDARY LAYER METHOD FOR UNSTEADY COMPRESSIBLE FLOWS Ph.D. Thesis
ROBERT EDWIN BARTELS 1994 199 p
Avail: Univ. Microfilms Order No. DA9424195

A time accurate compressible interactive boundary layer procedure for airfoils using the quasi-simultaneous method of Veldman is developed. It couples the high frequency transonic small disturbance equation with the complete set of unsteady compressible boundary equations in Levy-Lees variable form, using a pseudo-time derivative of displacement thickness for enhanced stability. Included is a simple procedure for time accurately updating the viscous wake location. The basis of the interaction is an extension of the asymptotic matching condition of Davis for unsteady compressible interaction. This analysis identifies several possible unsteady transonic separation structures and highlights the importance of the pseudo-time derivative in stabilizing the interaction. The method is applied to oscillating airfoils experiencing light shock-induced stall. Comparisons are made with several standard turbulence models. Shock-induced oscillatory flow about the 18 percent circular arc airfoil is investigated with this method and found to be modeled quite accurately. Dissert. Abstr.

N95-30304 Connecticut Univ., Storrs, CT.
THE FLUID MECHANICS OF A HIGH ASPECT RATIO SLOT WITH AN IMPRESSED PRESSURE GRADIENT AND SECONDARY INJECTION Ph.D. Thesis
JOHN BERTRAM SOBANIK 1993 258 p
Avail: Univ. Microfilms Order No. DA9419439

A high aspect ratio slot flow (which emulates the gas leakage path in a gas turbine engine outer turbine air seal) is studied by use of a high aspect ratio slot using water as the working fluid. The cross section of the geometry is similar to a 'T', the slot being the vertical stroke and the main flow being the cross bar. A pressure gradient in the axial direction is created by blocking the main flow at a discreet location with an orifice plate (or blade tip simulator), located above the slot. Seven individually metered secondary flow injectors are located periodically along the bottom of the wall of the slot. Two slot widths, 1/8 and 1/4 inch, were investigated for length to width aspect ratios of 384 and 192 and height to width aspect ratios 33.2 and 16.6 respectively. Orifice plate pressure drops sufficient to give Reynolds numbers based upon half width of the slot, without secondary injection turned on, of 2350 and 4700 in the 1/8 inch slot and 4700 and 9400 in the 1/4 inch slot were run. Various secondary injection scenarios were added to the flow, the cases most studied being the no-injection and the all injectors flowing equal mass rates. Total injection rates for all seven injectors of 3.78 and 7.56 slot volumes per second were run. Laser velocimetry data and flow visualization pictures using fluorescein dye in the secondary flow are compared with computational results form the TEACH 3-D computer code. Major features and trends of the flow are captured by the computational model. Recommendations for further improvement of the numerical accuracy involves modification of the TEACH 3-D code to allow the 'slip condition' on all confining boundaries of the flow, or using a code which permits the 'slip condition' on all boundaries as a built-in option.
Dissert. Abstr.

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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A95-87354
EURO-NOISE '92, LONDON, UK, SEPT. 14-18, 1992. BKS. 1-3
St. Albans, Hertz, UK Institute of Acoustics (Proceedings of the Institute of Acoustics, Vol. 14, Pt. 4) 1992 987 p.
(ISBN 1-873082-39-8; HTN-95-92534) Copyright

A conference of environmental noise in Europe produced three volumes of papers in the areas of noise standards and regulations, occupational and industrial noise, transportation noise, noise monitoring, noise reduction, environmental policies, noise-related hearing loss, community responses, noise annoyance, and acoustics. Environmental, social, and public health concems were discussed and some solutions were offered. Herner

A95-87355
POSSIBLE GUIDELINES FOR HELICOPTER NOSIE ASSESSMENT
A. P. BLOOMFIELD and B. M. SHIELD South Bank University, UK *In* Euro-noise '92, London, UK, Sept. 14-18, 1992, Bks. 1-3 St. Albans, Hertz, UK Institute of Acoustics (Proceedings of the Institute of Acoustics, Vol. 14, Pt. 4) 1992 p. 421-428
(HTN-95-92535) Copyright

Helicopters are one of the few noise sources for which generally accepted assessment criteria do not exist. As an altemative to simply applying the guidelines used for fixed wing aircraft, this paper approaches the derivation of assessment criteria for helicopters by applying standard methods and criteria established for other noise sources and attempts to adapt these to allow for the features peculiar to helicopters. It will concentrate on the situation where helicopter noise is to be introduced to existing buildings. Various possible indices or rating systems are considered and their suitability for helicopter noise examined. In many locations, assessments will have to be made by reference to particular circumstances (the use of a building, its noise insulation, the existing background noise level, etc.) but certain situations permit the suggestion of specific guidelines. In particular, a set of external noise criteria considered appropriate to domestic residences is proposed and its application to other types of buildings is discussed.
Author (revised by Herner)

A95-87356
THE EFFECTS AND PREDICTION OF ROTARY WING AIRCRAFT NOISE ON THE COMMUNITY
R. J. WESTON Royal Air Force Inst. of Health & Medical Training, Aylesbury, Bucks, UK *In* Euro-noise '92, London, UK, Sept. 14-18, 1992, Bks. 1-3 St. Albans, Hertz, UK Institute of Acoustics (Proceedings of the Institute of Acoustics, Vol. 14, Pt. 4) 1992 p. 429-435 Research sponsored by the Ministry of Defence
(HTN-95-92536) Copyright

Helicopter operations constitute a growing problem for both civil and military aviation due to an increasing number of day and night operations, lower flying altitudes, specific noise characteristics and a general tendency to operate nearer and nearer to communities. It has been said that helicopter noise has a number of unique characteristics, which has led to numerous studies into whether or not the indicies should be weighted to reflect these features. The University of Ulster carried out a review of three helicopter landing sites (HLS). Sound levels were measured at various locations outside dwellings in the villages neighboring the three sites. Locations were chosen for measurements at dwellings around the helipad both inside and outside the area presently delineated for insulation grants. The research concludes that there is little difference between the annoyance of helicopter noise and that of fixed wing jet aircraft. However, some workers suggest a 5dB weighting to allow for the impulsive nature of the blade slap noise.
Author (revised by Herner)

A95-87357
ENVIRONMENTAL NOISE MONITORING - SOURCE IDENTIFICATION
I. H. FLINDELL University of Southampton, Southampton, UK and P. WRIGHT University of Southampton, Southampton, UK In Euro-noise '92, London, UK, Sept. 14-18, 1992, Bks. 1-3 St. Albans, Hertz, UK Institute of Acoustics (Proceedings of the Institute of Acoustics, Vol. 14, Pt. 4) 1992 p. 437-444
(HTN-95-92537) Copyright

This paper describes progress made under a research to establish the potential for automatic noise source identification for use in field portable noise measurement systems. Such measurment systems must be capable of breaking down the overall noise environment into the equivalent continuous level (L(sub eq)) contributions made by each significant source to be of any practical use. It is important that the source identification system does not compromise the basic measurement accuracy achievable with a conventional sound level meter and microphone combination. On the other hand, the level of source identification required is limited to generic source types, e.g. aircraft, road traffic, etc. There is no need for identification down to the level of individual vehicles, as there is no practical use for this level of detail in this context. This project was limited to aircraft, road traffic, and railway noise as generic transportation noise sources, with discrimination against other sources of background noise having a high priority. Author (Herner)

A95-87362
THE USE OF THE EQUIVALENT CONTINUOUS SOUND LEVEL (L(SUB EQ)) AS AN AIRCRAFT NOISE INDEX
ROY E. CADOUX Civil Aviation Authority, UK *In* Euro-noise '92, London, UK, Sept. 14-18, 1992, Bks. 1-3 St. Albans, Hertz, UK Institute of Acoustics (Proceedings of the Institute of Acoustics, Vol. 14, Pt. 4) 1992 p. 41-48
(HTN-95-92542) Copyright

In order to assess the impact of aircraft noise on people living near airports, a number of methods have been developed to quantify the noise in terms which indicate its likely adverse effects upon people. These effects are numerous and complicated and, in practice, it has proved necessary to average both the human response variables and the noise exposure. This paper describes the use of the Equivalent Continuous Sound Level (L(sub eq)) for quantifying aircraft flight-noise exposure in the UK, and the development of the Civil Aviation Authority's (CAA's) aircraft noise contour model.
Author (revised by Herner)

A95-87363
AIRCRAFT NOISE AND SLEEP DISTURBANCE: A FIELD STUDY
C. J. JONES Civil Aviation Authority, London, UK and J. B. OLLERHEAD Civil Aviation Authority, London, UK *In* Euro-noise '92, London, UK, Sept. 14-18, 1992, Bks. 1-3 St. Albans, Hertz, UK Institute of Acoustics (Proceedings of the Institute of Acoustics, Vol. 14, Pt. 4) 1992 p. 119-128
(HTN-95-92543) Copyright

Rising demand for air transport is bringing increased pressure for more aircraft movements at night in order to make fuller use of existing airport capacity. But public acceptance of night traffic is low; it has long been held by environmental groups that people are especially sensitive to noise at night and that sleep disturbance is a particularly harmful effect of environmental noise. In recognition of this the UK Government has implemented 'night restrictions' policies which limit aircraft movements at Heathrow and Gatwick Airports. Any future changes to the night restriction policies at Heathrow and Gatwick need to be supported by reliable scientific evidence as to the likely environmental effects. Accordingly, the Department of Transport asked the Civil Aviation Authority to undertake a major study of aircraft noise and sleep disturbance. This paper outlines the approach which was taken to this study and describes the experimental work which was carried out; the results of the work are still being analyzed so the details of the findings of the study are not yet available. Author (Herner)

A95-87364
NOISE LEVELS OF HELICOPTERS PERFORMING ELEVATED PAD TAKE-OFF AND LANDING PROCEDURES
B. C. POSTLETHWAITE Acoustic Technology Limited, Southampton, UK *In* Euro-noise '92, London, UK, Sept. 14-18, 1992, Bks. 1-3 St. Albans, Hertz, UK Institute of Acoustics (Proceedings of the Institute of Acoustics, Vol. 14, Pt. 4) 1992 p. 153-162
(HTN-95-92544) Copyright

The take-off flight profile from an elevated helipad is typified by an initial period in hover close to the pad, followed by a slow rearwards or vertical ascent to a height of about 30-40 m above the helipad and then transition into forward motion and climb away. In the course of preparing technical evidence in relation to the noise environment in the vicinity of a proposed elevated helipad, very little measured data on helicopters performing such maneuvers was identified. Extensive noise measurements were therefore undertaken by the author on three separate types of helicopters performing these types of maneuvers. The results of some of these measurements are presented here together with a brief discussion on two specific technical issues concerned with the prediction of helicopter noise levels close to helipads. Author (revised by Herner)

A95-87377
ENVIRONMENTAL ASPECTS OF ORBITAL TRANSPORT:
H. GRABL Max-Planck-Institute for Meteorology, Hamburg, Germany *In* Orbital transport: Technical, meteorological and chemical aspects; Aerospace Symposium, 3rd, Braunschweig, Germany, Aug. 26-28, 1991. A95-87373 Berlin, Germany Springer-Verlag 1991 p. 53-61
Copyright

A first environmental impact assessment for the planned hypersonic air-breathing space transportation system SANGER has revealed: Water vapor and nitrogen oxide emissions mainly into the flight channel at approximately 26 km height would neither cause a remarkable ozone depletion nor enhance stratospheric water vapor concentration appreciably nor contribute significantly to polar stratospheric clouds, as long as restricted to a few starts per month only. However, if a small portion of air traffic would become hypersonic, stratospheric ozone were depleted as strongly as by decay products of chlorofluorocarbons and thus would not be tolerable unless at least nitrogen oxide emissions were strongly reduced. Author (Herner)

A95-88457
INTER-NOISE 92: NOISE CONTROL AND THE PUBLIC; INTERNATIONAL CONGRESS ON NOISE CONTROL ENGINEERING, TORONTO, ONTARIO, CANADA, JULY 20 - 22, 1992. VOLS. 1 & 2
GILLES A. DAIGLE, editor and MICHAEL R. STINSON, editor New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 1,264 p.
(ISBN 0-931784-25-5; HTN-95-11994) Copyright

A conference was held concerning noise control and the public, to which 270 papers were presented in the following sessions: (1) Emission: Noise Sources, (2) Physical Phenomena and Noise Control Elements, (3) Vibration and Shock: Generation, Transmission, Isolation and Reduction, (4) Immission: effects of Noise, (5) Analysis, and (6) Requirements. Several special sessions were organized relating to noise control materials and structures, various types of transportation noise, and future trends in noise control. Three plenary lectures were delivered concerning: (1) airport noise, (2) quieter products, and (3) the building envelope as a shield against external noise. For individual titles, see A95-88458 through A95-88480. Herner

A95-88474
TIME-AVERAGE AIRCRAFT NOISE DESCRIPTORS: CONFUSION WITH NO BENEFIT
PAUL D. SCHOMER US Army Construction Engineering Research Lab., Champaign, IL, US *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 987-992
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For aircraft noise, single events should be described by their sound exposure (SE) and their maximum sound level. The only 'decibel' used should be reserved for maximum level (maxiumum A-level, slow). For nighttime events, the sound exposure is multiplied by 10. The measurement unit used for land use planning and noise contours should be the total day-night sound exposure (DNSE). The only 'average' used should be the Yearly Average (Total) Day-Night Sound Exposure (YDNSE), the average which can be understood by the lay public. Author (Herner)

A95-88475
NOISE METRICS AND AVIATION NOISE CONTROL: THE CASE FOR DNL
JOHN E. WESLER Wyle Lab., Arlington, VA, US *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 993-996
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In 1980, the Day-Night Average Sound Level (DNL) was generally accepted as a means for assessing community noise impacts of various activities, including airports. This paper demonstrates the continued validity of DNL because it meets the following criteria for a useful metric: (1) it is a means for measuring the characteristic involved, in this case, community noise; (2) it provides reasonable guidelines for normally acceptable levels of that characteristic; and (3) it provides a single unambiguous method to represent the characteristic (different individuals applying the same information should arrive at the same result). Supplemental noise metrics may be applied to DNL for specific purposes, but this metric remains the best basic descriptor of community noise. Herner

A95-88477
CRITICISM OF THE LEQ AS AN INDEX FOR AIRCRAFT NOISE AND OTHER DISCONTINUOUS NOISE SOURCES
A. LOOTEN U.E.C.N.A, Vernier, Switzerland *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 1003-1006
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This paper presents an analysis of results of numerous studies concerning the degree of annoyance response to various levels of aircraft noise around airports. This analysis leads to the conclusion that the commonly employed noise measurement index, Equivalent Continuous Sound Level (Leq), is misleading. Both noise surveys and laboratory experiments show the inadequacy of the Leq to assess the public annoyance from aircraft noise during the day. Sleep disturbances are best correlated with the maximum level and the number of noise events. The Q Index or the WECPNL Perceived Noise Level proposed by some researchers (discussed in the paper) are best suited to evaluate the acceptability of sites that are exposed to aircraft noise. Herner

A95-88478
CRITICISM OF THE LEQ AS AN INDEX FOR AIRCRAFT NOISE AND OTHER DISCONTINUOUS NOISE SOURCES
JAMES M. FIELDS *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 1007-1010
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This paper discusses possible health implications for the population due to the impact of aircraft noise during the night on sleep. A method is proposed for measuring the health effects of aircraft noise based on alterations of sleep patterns observed in populations in areas surrounding an airport. A method is presented for calculating the Annual Number of Noise-induced Awakenings (ANNA). This is proposed as the criterion for determining the areas with possible health implications for the population. Hemer

A95-88480

ASSESSMENT OF HELICOPTER NOISE ANNOYANCE: A COMPARISON BETWEEN HELICOPTERS AND JET AIRCRAFT

TRULS GJESTLAND Acoustics Research Center, Trondheim, Norway, IDAR L. N. GRANOIEN Acoustics Research Center, Trondheim, Norway, KARE H. LIASJO Acoustics Research Center, Trondheim, Norway, and HEROLD OLSEN Acoustics Research Center, Trondheim, Norway *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 1023-1028 Research sponsored by the Norwegian Civil Aviation Administration

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At equal noise levels, the noise from a helicopter is judged more or less annoying than the noise from a jet aircraft, depending on the type of helicopter. This study indicates that the present procedure specified by the Norwegian Aircraft Noise Abatement Commission, and used by Norwegian authorities for assessing the environmental impact from helicopter noise; i.e., imposing a 5-decibel-B 'penalty', overestimates the influence of the possible impulsive character of this type of noise. In communities where helicopter noise seems to have an impact on the community, particularly around the heliports serving the oil installations in the North Sea, the majority of the traffic consists of large-type helicopters, that, according to our study, may be even less annoying than regular jet aircraft. We therefore recommend that no impulse adjustment be made when assessing the environmental impact from helicopter noise. This recommendation applies both for heliports and ordinary airports.

Author (revised by Hemer)

A95-90090

PAST AND PRESENT UK RESEARCH ON AIRCRAFT NOISE EFFECTS

J. B. OLLERHEAD Civil Aviation Authority, London, UK In Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 9-18

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Airport planning and the implementation of effective aircraft noise abatement practices require a good understanding of the relationships between the physical dimensions of aircraft noise exposure and its effects upon people living near airports. These effects may be divided into two groups, direct and indirect. The direct effects are the disturbances of people's activities caused by the noise. The indirect effects are people's responses to that disturbance; over a period of time they may become annoyed and they may complain. However, numerous studies of complaint reactions have shown that complaints are poorly correlated with noise exposures and do not provide a reliable guide to its true effects. Accordingly, in the United Kingdom (UK), attention has focused on the relationships between noise exposure variables and annoyance. Examples of past Civil Aviation Authority (CAA) research commissioned by the Department of Transportation (DOT) are the 1961 and 1967 social surveys of noise annoyance around London (Heathrow) Airport, the surveys of night noise disturbance at Heathrow and Gatwick carried out in 1980 and 1984, and the comprehensive UK Aircraft Noise Index Study of 1982. Other research aimed at more restricted but nevertheless important problems, include the 1982 study of helicopter noise disturbance, and the 1981 and 1986 surveys of public reactions to general and business aviation noise. Two further studies are currently nearing completion. One, relatively small, involves an attempt to shed more light on the question of whether or not people find helicopter noise more annoying than fixed-wing aircraft noise. The other is a major field study of the effects of aircraft noise on sleep. This paper considers the aims and results of the CAA research and the consequences for practical aircraft noise assessment. Author (revised by Hemer)

A95-90095

AIRCRAFT NOISE AT A WEST COAST AIRPORT IN THE NEXT CENTURY

EDWARD F. HABOLY Vancouver International Airport Authority, Richmond, Canada *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 85-90

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With the legislated phaseout of older technology Stage 2 jet aircraft from the civil aviation fleet, most international airports will experience a considerable decrease in cumulative and single-event noise exposure by the year 2002. However, as the fleet mix changes to accomodate the growth in passenger activity, there will be an increased proportion of heavier wide-body aircraft in the fleet. This will be most prevalent at West Coast international airports which will need to accomodate increased traffic from the Orient. Although all of these aircraft will be newer technology Stage 3 aircraft, they are in some cases noisier than the lighter narrow-body Stage 2 aircraft which they have succeeded. The greatest proportion of jet aircraft flying in the next 25 years will be aircraft built with twentieth century technology, as even the proposed 'stretches' and 'super-jumbos' will be equipped with current technology engines. Given this outlook, airports may be required to investigate new methods of mitigating the new noise exposure, which may result in increased on aircraft operations. In addition, communities surrounding airports will have to re-examine their land use plans to prevent non-compatible development from following the pre-year-2002 shrinking noise contours, as the year 2002 noise regime may be the minimum achievable for the foreseeable future. Author (Hemer)

A95-90111

HANGARS AS NOISE BARRIERS FOR HELICOPTER NOISE

LARRY PATER U.S. Army Construction Engineering Research Labs., Champaign, IL, US and RAMAN YOUSEFI Illinois Univ., Urbana, IL, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 241-246

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A barrier interposed between source and receiver does not achieve a total acoustical shadow because some sound energy is diffracted around the edges of the barrier into the shadow zone. The amount of diffraction that occurs depends on the wavelenth of the sound relative to the size of the barrier; the longer wavelength of a lower frequency means more diffraction around the barrier edge and thus less noise reduction. Helicopter noise is typically quite strong at lower frequencies, so that an effective noise barrier must be large. This reduces the probability that such noise barriers will be constructed, since they are of use primarily only while the helicopter is on ground, during warmup and checkout. The project investigated the amount of insertion loss available from using aircraft hangars or similar large buildings as noise barriers for helicopters operating on or near the ground. This investigation is apart of the U.S. Army Construction Engineering Research Laboratories' continuing effort to develop techniques for mitigating community noise disturbance due to military activities. Author (Hemer)

A95-90112
REDUCING LOW FREQUENCY NOISE EMISSIONS FROM A LANGLEY AIR FORCE BASE HUSH-HOUSE
MORTON I. SCHIFF Industrial Acoustics Co., Inc., Bronx, NY, US, DAVID A. COLLINGS Industrial Acoustics Co., Inc., Bronx, NY, US, and MARTIN HIRSCHORN Industrial Acoustics Co., Inc., Bronx, NY, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 303-308
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Quick reaction by the United States Air Force to an aircraft noise complaint, caused by ground run-up testing at Langley Air Force Base, resulted in a technological break-through in the form of a jet noise diffuser to control low frequency noise. As a result, the Air Force was able to remain a good neighbor to a nearby single private home. The Air Force's program over the last decade to improve community relations, with due regard to personnel safety, has been very successful. It included the worldwide implementation of noise control procedures during ground testing of USAF fighter aircraft. The noise control program primarily consisted of demountable 'Hush-Houses', allowing testing of completely enclosed aircraft or jet engines mounted on thrust stands at any engine power setting. Author (Herner)

A95-90115
STANDARDIZATION OF AIRCRAFT NOISE INSULATION MEASURES WITHOUT COMPROMISING RESULTS
DANA S. HOUGHLAND David L. Adams Associates, Inc., Denver, CO, US and MICHAEL B. BARNHARDT David L. Adams Associates, Inc., Denver, CO, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 329-332
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A program to bring noise relief to all owner-occupied homes within the 70 L(sub dn) contour surrounding a major metropolitan airport allowed investigation of many innovative methods. Among the innovations included were: criteria based on improvement in noise reduction rather than total noise reduction, using a systematic construction survey method rather than acoustical testing of each home, a maximum monetary cap on construction costs of each home, and cooling and ventilation techniques utilizing evaporative cooling. The Stapleton Noise Insulation Program (SNIP) is a project fully funded by the City and County of Denver. Of the original 3600 homes potentially eligible, a total of 2296 eventually participated in the program. Most homes which dropped out of the program did so due to sale or repossession of the home. The program also included churches and schools located within the 65 L(sub dn) contour. The results presented herein show that the acoustical performance improvements were substantial, consistently exceeding a 10 dB improvement in A-weighted noise reduction. Public response has also been extremely positive. Construction costs were capped at $7500.00 per home and average administrative costs were held to approximately 10% of construction costs. Author (Herner)

A95-90118
A REVIEW OF AIR FORCE POLICY AND NOISE MODELS PERTAINING TO THE NOISE ENVIRONMENT UNDER LOW-ALTITUDE, HIGH-SPEED TRAINING AREAS
BRENDA W. COOK U.S. Air Force, Langley AFB, VA, US and MICHAEL J. LUCAS Wyle Labs., Arlington, VA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 373-378
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This paper summarizes U.S. Air Force requirements and monitoring methods relating to noise generated at low-altitude high-speed military training areas. Significant noise sources at training areas are identified. The paper presents Air Force policy, FAA requirements of the National Environmental Policy Act as they relate to noise from military training areas. Various computer models of noise propagation are presented and their uses are discussed. The paper summarizes methods for complying with environmental impact statements requirements for noise, including estimation of exposed population. Herner

A95-90119
THE EFFECT OF ONSET RATE ON ANNOYANCE TO MILITARY AIRCRAFT NOISE
ERIC STUSNICK Wyle Labs., Arlington, VA, US, KENNETH J. PLOTKIN Wyle Labs., Arlington, VA, US, KEVIN A. BRADLEY Wyle Labs., Arlington, VA, US, and JOHN A. MOLINO Tech-U-Fit Corp., Arlington, VA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 379-384
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Preliminary assessments of the noise environments under military training routes suggested that, in addition to the sound level of the events, their high onset rate and infrequent, irregular occurence may play a major role in determining human annoyance. To account for the estimated effect of onset rate, an interim acoustic metric, L(sub dnmr) (onset rate corrected, busiest month, day-night average sound level), was recommended to describe the average noise exposure from low-altitude military training flight operations. The L(sub dnmr) metric was subsequently adopted by the Air Force for use in assessing community noise impact from military training routes. The fact that onset rate contributes annoyance that adds to the annoyance produced by the acoustic level of the flyover has been further confirmed by independent Air Force experiments. The L(sub dnmr) metric adds onset rate adjustments to the individual aircraft overflight sound exposure levels (SELs) that are used to compute the busiest month, day-night average sound level (L(sub dnm)). Apart from the addition of this adjustment, the L(sub dnmr) is computed in the same manner as is L(sub dnm). This paper reports on two programs which have recently been completed to more accurately assess human annoyance to noise from low-altitude military training flight operations. The first is a highly controlled laboratory study in inherently artificial indoor and outdoor settings; the second is a less controlled study in the more normal setting of a rented home. Both studies confirmed the existence of an onset rate effect and each indicated that the interim onset rate correction could be extended beyond 5 dB to at least 11 dB at an onset rate of 150 dB per second. Author (revised by Herner)

A95-90121
DEVELOPMENT AND FIELD TEST OF THE BETA VERSION OF THE USAF ASSESSMENT SYSTEM FOR AIRCRAFT NOISE (ASAN)
B. ANDREW KUGLER BBN Systems and Technologies, Canoga Park, CA, US, PAUL A. SHARP Ball System Engineering Div., Fairborn, OH, US, and LAWRENCE S. FINEGOLD USAF Armstrong Lab., Wright-Patterson AFB, OH, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 393-398
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As part of its responsibilities under the National Environmental Policy Act (NEPA), the United States Air Force (USAF) must prepare environmental impact assessments of contemplated changes in aircraft operations. The effects of aircraft noise on humans, animals and structures are arguably the most important environmental issues that must be addressed in USAF Environmental Impact Analysis Process (EIAP) documents. In support of this need, the Armstrong Laboratory is developing and field testing the Assessment System for Aircraft Noise (ASAN). When fielded, ASAN will provide USAF route and environmental planners the capability to produce technically and legally defensible aircraft noise-related environmental impact analyses. ASAN is designed to benefit from recent advances in computer software and hardware. These include Geographic Information System (GIS) technology, relational database management software capabilities, the availability of national digital databases, improvements in aircraft noise prediction models, and the development of new models to predict the effects of aircraft noise on humans, animals and structures. ASAN combines these capabilities into an easy to use computer program that will allow the USAF planners to: (1) perform environmental noise impact analyses for military training routes (MTRs) and military operations areas (MOAs), (2) organize and greatly simplify the task of predicting and analyzing the effects of changes in both subsonic and supersonic aircraft operations, and (3) generate output (maps, tables and draft text) consistent with the NEPA requirements for EIAP documents. Author (revised by Herner)

A95-90122
ENVIRONMENTAL NOSIE RESEARCH USING THE HUMAN RESPONSE MONITOR (HRM). PHASE 1: SYSTEM DEVELOPMENT
MATTHEW D. SNEDDON BBN Systems and Technologies, Canoga Park, CA, US and LAWRENCE S. FINEGOLD Armstrong Lab., Wright-Patterson AFB, OH, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 399-402
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Field studies of effects of aircraft noise which can overcome the limitations of conventional assumptions and data collection methods require experimental designs in which close linkages may be established between sporadic noise exposure and both immediate and long term human response. This requirement implies needs for efficient means of dealing with low data rates (perhaps as low as a few flyovers and responses per week), long study durations, cost-effective measurement of noise exposure, and real time recording of response information. Current commercially available noise dosimeters, although small in size, are designed for limited applications focused on specialized monitoring of a limited range of high level industrial exposures. These devices perform only specialized (hearing conservation-related) data collection, do not monitor human attitudinal and behavioral responses, and are not in general adaptable for broader research purposes. A portable, battery-operated instrument, called the Human Response Monitoring (HRM) has recently been designed to fulfill such study needs. This paper describes the design and development of the miniaturized, computer-based instrumentation HRM system for the long term, simultaneous real-time monitoring of environmental noise exposure and human response. Because the system incorporates a general purpose microprocessor and is fully digital, it is flexible enough to be adapted to many applications. Instrumentation of the sort described in this paper can support research designs combining the rigor of laboratory measurement with the face validity of field studies. Author (revised by Herner)

A95-90125
THE EVOLUTION OF AIRPORT NOISE MONITORING SYSTEMS: RECENT ACHIEVEMENTS AND FURTHER NEEDS
EDWARD M. BALDWIN, III Harris Miller Miller & Hanson, Inc., Lexington, MA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 415-420
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Airport noise monitoring systems have evolved from inflexible-single-purpose acoustic measurement systems into powerful, multipurpose systems that support analysis of a broad range of parameters related to airport noise. These parameters can include airport activity, runway use, flight tracks, aircraft performance, weather data, complaints, and more. Today, 'noise monitoring systems' is a misnomer; a more appropriate term is 'noise and operations monitoring systems.' Author (Herner)

A95-90127
FEATURES OF MASSPORT'S NEW NOISE MONITORING SYSTEM
NANCY S. TIMMERMAN Massport, Boston, MA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 425-428
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For the past several years, Massport has been installing a new noise monitoring system for Logan Airport and Hanscom Field. The system includes noise, operational, weather and mapping components. The system is in the final stages of completion. This paper will discuss the main features of the system, and will go into more detail about its more novel components. Author (Herner)

A95-91519
RESEARCH OF THE METHOD FOR EVALUATING NOISE CAUSED BY SONIC BOOM
AYANO TOKUYAMA Kawasaki Heavy Industries Ltd., Japan, HIDETO TAYA IPRI, Japan, and HIROSHI TANAKA IADF, Japan *In* Aircraft Symposium, 30th, Tsukuba, Japan, Sep. 30 - Oct. 2, 1992. A95-91491 Japan Japan Aerospace Association 1992 p. 196-199 In JAPANESE
Copyright

In many countries, supersonic flights overland by commercial aircraft is forbidden. If that restriction were eliminated, the economic advantage would be significantly increased for the airlines. For attempting supersonic flight overland, first, we must find out the proper method of evaluating the noise of sonic boom which has not been established yet. Then, we research the acceptability of the noise for humans. Our research of the noise of sonic booms by loudspeaker driven simulation system is described. Author (Herner)

A95-91870
MOMENTUM AND SCALAR TRANSFER COEFFICIENTS OVER AERODYNAMICALLY SMOOTH ANTARCTIC SURFACES
RICHARD BINTANJA Utrecht University, Utrecht, Netherlands and MICHIEL R. VAN DEN BROEKE Utrecht University, Utrecht, Netherlands Boundary-Layer Meteorology (ISSN 0006-8314) vol. 74, no. 1-2 April 1995 p. 89-111 Research sponsored by the Netherlands Antarctic Research Programme and the Dutch National Research Programme on Global Air Pollution and Climate Change (HTN-95-92932) Copyright

Vertical profiles of wind speed, temperature and humidity were used to estimate the roughness lengths for momentum (z(sub 0)), heat (z(sub H)) and moisture (z(sub Q)) over smooth ice and snow surfaces. The profile-measurements were performed in the vicinity of a blue ice field in Queen Maud Land, East Antarctica. The values of z(sub 0) over ice (approximately 3 x 10(exp -6) m) seem to be the smallest ever obtained over permanent, natural surfaces. The settling of snow on the ice and the loss of momentum at saltating snow particles serve as momentum dissipating processes during snow-drift events, expressed as a strong dependence of z(sub 0) on u(sub *). The scalar roughness lengths and surface temperature can be evaluated from the temperature and humidity profile measurements if the ratio z(sub H)/z(sub Q) is specified. This new method circumvents the difficult measurement of surface temperature. The scalar roughness lengths seem to be approximately equal to z(sub 0) for a large range of low roughness Reynolds numbers, despite the frequent occurrence of drifting snow. Possible reasons for this agreement with theory of non-saltating flow are discussed. Author (Herner)

N95-29110 Minnesota Univ., Minneapolis, MN.
EXPERIMENTS ON MICROBURSTS Ph.D. Thesis
JIE YAO 1994 166 p

Avail: Univ. Microfilms Order No. DA9420114

An isolated dynamic microburst is modelled in our laboratory by releasing a volume of salt water solution which is slightly heavier than ambient fresh water, allowing it to fall onto a horizontal plate and develop into a turbulent microburst vortex ring. Several visualization methods are used to observe the event and a high resolution video camera is used to record it. Quantitative results are achieved in two ways. The descending rates and wind front positions of the modelled microburst are measured from the video record by means of a digitizing cursor on a monitor. A cross wire type hot film anemometer is utilized to detect the transient wind velocity induced by the vortex ring at different radial positions near the impact center. Ensemble averaging methods are applied to get an average velocity time traces. An inviscid scaling law is derived from the Boussinesq approximation and is used to present the experimental results in an appropriate dimensionless form. This model exhibits many of the features of naturally occurring microbursts which are known to be a hazard to aviation. Experimental results are in good agreement with the real microburst DL191, which occurred at Dallas Fort-Worth airport in August 1985, and with an 'average' microburst abstracted from field investigations. Dissert. Abstr.

N95-29160# Army Cold Regions Research and Engineering Lab., Hanover, NH.

ANALYZING THE STABILITY OF FLOATING ICE FLOES

BARRY COUTERMARSH and RANDY MCGILVARY Dec. 1994 27 p

(AD-A292149; CRREL-94-13) Avail: CASI HC A03/MF A01

This report describes an experimental study to measure the pressure caused by fluid acceleration beneath a floating parallelepiped block. Dynamic fluid pressure was measured at discrete points beneath the block for several flow velocities, flow depths, block angles of attack and block-thickness-to-depth ratios. The measured pressures were used to calculate block underturning moments, and a hydrostatic analysis was used to calculate a block righting moment. From this, a densimetric Froude undertuning criterion is presented. The measured hydrodynamic pressure distribution on the bottom of a single model ice floe is used to estimate the dynamic stability at three thickness-to-depth ratios. The energy-based analysis details the conditions required for instability, metastability and stability. At three thickness-to-depth ratios, block rotational inertia has the effect of reducing the Froude stability number by 5 to 10% over a completely static stability criterion. DTIC

N95-29797 Toronto Univ. (Ontario).

HAILSTONE HEAT AND MASS TRANSFER MEASUREMENTS Ph.D. Thesis

BLAIR JOHN WILLIAM GREENAN 1993 128 p

(ISBN-0-315-86304-8) Avail: Univ. Microfilms Order No. DANN86304

Results of experiments performed in an icing tunnel demonstrate, for the first time, that existing theory accurately describes the heat and mass transfer of individual hailstones growing in a supercooled cloud. The experiments were carried out using spheroidal ice models with a major axis diameter of 2 cm and aspect ratio of 0.67. In previous hail growth studies in the University of Toronto icing tunnel, air speed, pressure, temperature, and hailstone size were coupled to atmospheric free fall conditions. In the present study, the four controllable icing parameters are varied independently over the following ranges: air temperature: 21 C less than or equal to t(sub a) less than or equal to 3 C; air speed: 9 m/s less than or equal to V(sub a) less than or equal to 24m/s; air pressure: 40 kPa less than or equal to P(sub a) less than or equal to 100 kPa; and cloud liquid water content: 1 g m(exp -3) less than or equal to W(sub f) less than or equal to 5 g m(exp -3). Icing time, ice and water mass of the hailstone deposit, and major and minor axis diameters are measured to determine the rate of mass transfer by accretion of supercooled droplets from the air flow. An infrared imaging system is used to measure local and mean hailstone surface temperature, thereby allowing closure of the heat and mass transfer equation. Experiment results are used to calculate two unknown in the heat and mass balance equations: the Nusselt number, Nu, and the net collection efficiency, E(sub net). For experiments with no shedding of accreted water, the net collection efficiency is best described by E(sub net) = 0.59 K(exp 0.15) over the Stokes parameter range 6 less than K less than 18. This result is not inconsistent with the analytic solutions of Langmuir and Blodgett (1946) for potential flow over a sphere. Heat transfer measurements indicate that a relationship of Nu = 0.15 Re(exp 0.69) is appropriate for the Reynolds number range 13000 less than or equal to Re less than or equal to 50,000. This Re range is representative of small (approximately 1 cm) to medium-sized (approximately 3 cm) hailstones in free-fall. The Nusselt number results are 60 percent larger than those compiled by Whitaker (1972) for smooth spheres. Approximately 30 percent of this enhancement can be attributed to hailstone surface roughness. The present study provides a substantial improvement over the parameterizations of hailstone heat transfer currently used in computer models of severe convective storms. Dissert. Abstr.

N95-29830 Harvard Univ., Cambridge, MA.

IN SITU MEASUREMENTS OF CLO AND IMPLICATIONS FOR THE CHEMISTRY OF INORGANIC CHLORINE IN THE LOWER STRATOSPHERE Ph.D. Thesis

LINNEA MARIE AVALLONE 1993 278 p

Avail: Univ. Microfilms Order No. DA9421935

The role of anthropogenic chlorine compounds in wintertime polar ozone loss has been extensively examined. However, the causes of smaller, yet geographically more pervasive, declines in ozone over mid-latitudes are unknown. Measurements of chlorine oxide (ClO) from the NASA ER-2 aircraft and balloon platforms are analyzed to assess the contribution of chlorine to lower stratospheric ozone loss and the effects of heterogeneous chemistry on sulfate aerosols on the observed distributions of ClO. We employ the technique of chemical conversion/resonance fluorescence, in which nitric oxide converts ClO to chlorine atoms, which are detected by resonant scattering at 118.9 nm. The results of experiments that gauge the purity of resonance lamps, the kinetics of the conversion process, the flow characteristics within the instrument and the low-pressure chlorine atom calibration are presented. The effect of the equilibrium process Cl + O2 reversibly yields ClOO is investigated over the range of stratospheric temperatures and pressures. Each of these tests provides important data for determining the overall uncertainty of ClO measurements. In situ measurements of ClO obtained with a new balloon-borne instrument provide a test for our understanding of mid-latitude lower atmosphere chemistry. Dissert. Abstr.

N95-29885 Johns Hopkins Univ., Baltimore, MD.

INDUCED COMPTON SCATTERING BY RELATIVISTIC ELECTRONS IN MAGNETIZED ASTROPHYSICAL PLASMAS Ph.D. Thesis

MARK WILLIAM SINCELL 1994 118 p

Avail: Univ. Microfilms Order No. DA9420036

The effects of stimulated scattering on high brightness temperature radiation are studied in two important contexts. In the first case, we assume that the radiation is confined to a collimated beam traversing a relativistically streaming magnetized plasma. When the plasma is cold in the bulk frame, stimulated scattering is only significant if the angle between the photon motion and the plasma velocity is less than gamma(sup -1), where gamma is the bulk Lorentz factor. Under the assumption that the center of the photon beam is parallel to the bulk motion, we calculate the scattering rate as a function of the angular spread of the beam and gamma. Magnetization changes the photon recoil, without which stimulated scattering has no effect. It also introduces a strong dependence on frequency and polarization if the photon frequency matches the electron cyclotron frequency, the scattering rate of photons polarized perpendicular to the magnetic field can be substantially enhanced relative to Thomson, and if the photon frequency is much less than the cyclotron frequency the scattering is suppressed. Applying these calculations to pulsars, we find that stimulated scattering of the radio beam in the magnetized wind believed to exist outside the light cylinder can substantially alter the spectrum and polarization state of the radio signal. We suggest that the scattering rate is so high in some pulsars that the ability of the radio signal to penetrate the pulsar magnetosphere requires modification of either the conventional model of the magnetosphere or assumptions about the effects of stimulated scattering upon a beam. In the second case, we present a model of the radio emission from synchrotron self-absorbed sources, including the effects of induced Compton scattering by the relativistic electrons in the source. Order of magnitude estimates show that stimulated scattering becomes the dominant absorption process when (kT(sub B)/m(sub e) c(sup 2)) tau(sub T) is approximately greater than 0.1. Numerical simulations demonstrate that relativistic induced Compton scattering limits the brightness temperature of a self-absorbed synchrotron source to T(sub B) approximately less than a few x 10(exp 11) K and can significantly flatten the radio spectrum. The radio spectrum of the core of 3C279 is well matched by a model in which stimulated scattering is important, and the additional constraint T(sub B) approximately less than 2 x 10(exp 11) K may be important to the interpretation of the broad band spectra in variable extra-galactic compact radio sources (Landau, et al 1986). Stimulated scattering reduces the amplitude of the radio frequency variability relative to the x-ray variability, an effect which can be detected by multi-wavelength variability studies. Data for a sample of resolved compact radio cores (Ghisellini, et al. 1993) indicate that it is inconsistent to neglect induced Compton scattering stratospheric (16 to 30 km) chlorine chemistry. The observations are compared to a photochemical model which incorporates hydrolysis of N2O5 on sulfate aerosols. This yields good agreement between calculation and measurement, except below 20 km where observed ClO is greater by up to a factor of four. In a model constrained to reproduce observed ClO below 20 km, the ozone loss rate is dominated by HO(x) and halogen oxide catalytic cycles, which may help to explain the observed negative ozone trends in the lower stratosphere. Data from the Airborne Arctic Stratospheric Expedition 2 are compared with measurements made at similar latitudes and seasons during earlier ER-2 flight series to assess the effects of the Mt. Pinatubo eruption on the partitioning of inorganic chlorine. While the comparisons show little enhancement in ClO poleward of 40 deg N, there is a substantial increase between 20 deg and 40 deg N. These results are indicative of volcanic perturbation to stratospheric chemistry via enhanced sulfate aerosol loading.

Dissert. Abstr.

N95-30016# National Renewable Energy Lab., Golden, CO.
EXPERIMENTAL INVESTIGATION OF AERODYNAMIC DEVICES FOR WIND TURBINE ROTATIONAL SPEED CONTROL, PHASE 1
L. S. MILLER (Wichita State Univ., Wichita, KS.) Feb. 1995 49 p
(Contract(s)/Grant(s): DE-AC36-83CH-10093)
(DE95-004034; NREL/TP-441-6913) Avail: CASI HC A03/MF A01

An investigation was undertaken to identify the aerodynamic performance of five separate trailing-edge control devices, and to evaluate their potential for wind turbine overspeed and power modulation applications. A modular two-dimensional wind tunnel model was constructed and evaluated during extensive wind tunnel testing. Aerodynamic lift, drag, suction, and pressure coefficient data were acquired and analyzed for various control configurations and angles of attack. To further interpret their potential performance, the controls were evaluated numerically using a generic wind turbine geometry and a performance analysis computer program. Results indicated that the Spoiler-Flap control configuration was best suited for turbine braking applications. It exhibited a large negative suction coefficient over a broad angle-of-attack range, and good turbine braking capabilities, especially at low tip-speed ratio. DOE

N95-30200# Technische Univ., Delft (Netherlands).
PREDICHAT: FIRST ORDER PERFORMANCE CALCULATIONS OF WINDTURBINE ROTORS USING THE METHOD OF THE ACCELERATION POTENTIAL
G. J. W. VANBUSSEL Oct. 1993 240 p
(PB95-206454; IW-93069R) Avail: CASI HC A11/MF A03

A method is described for the calculation of aerodynamic loads on a horizontal axis wind turbine rotor. The method is based upon acceleration potential theory. An approximate solution of the boundary value problem has been obtained using a matched asymptotic expansion technique. Furthermore a numerical integration procedure has been applied for the integration of the pressure field gradient necessary for fulfillment of the final boundary condition. A partial delinearization of the method concerning the axial induction velocities turned out to be necessary. This is carried out in a numerical integration step. NTIS

15
MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A95-86862
MODELING STUDENT KNOWLEDGE WITH SELF-ORGANIZING FEATURE MAPS
STEVEN A. HARP Honeywell Technology Cent, Minneapolis, MN, United States, TARIQ SAMAD, and MICHAEL VILLANO IEEE Transactions on Systems, Man and Cybernetics (ISSN 0018-9472) vol. 25, no. 5 May 1995 p. 727-737 refs
(BTN-95-EIX95262697073) Copyright

The paper describes a novel application of neural networks to model the behavior of students in the context of an intelligent tutoring system. Self-organizing feature maps are used to capture the possible states of student knowledge from an existing test database. The trained network implements a universal student knowledge model that is compatible with recently developed Knowledge Space Theory approaches to student assessment and computer aided instruction. The student model can be applied to rapidly assess the knowledge of any given student, and chart a path from lower to higher states of expertise. We illustrate the concept on an aircraft fuel management domain, demonstrating its noise-tolerance and insensitivity to feature map parameter values. An approach to determining the correct feature map size is also described.

Author (EI)

A95-87205
QUALITY ESTIMATES AND STRETCHED MESHES BASED ON DELAUNAY TRIANGULATIONS
JENS-DOMINIK MUELLER von Karman Institute for Fluid Dynamics, Rhode-St.-Genese, Belgium AIAA Journal (ISSN 0001-1452) vol. 32, no. 12 December 1994 p. 2372-2379
(HTN-95-42575) Copyright

An unstructured grid generation method based on the Delaunay triangulation is presented that is capable of generating stretched layers along surface lines while retaining control over maximum angles. The method requires only minimum user input on the form of a set of boundary vertices, the character of each boundary, the thickness of the stretched layer, and the maximum aspect ratio desired. Upper and lower angular bounds are estimated and the grid quality is analyzed statistically. Author (Herner)

A95-88175
TRAJECTORY OPTIMIZATION USING PARALLEL SHOOTING METHOD ON PARALLEL COMPUTER
D. J. WIRTHMAN Texas A&M Univ, College Station, TX, United States, S.-Y. PARK, and S. R. VADALI Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 18, no. 2 March-April 1995 p. 377-379 refs
(BTN-95-EIX95282706670) Copyright

The efficiency of a parallel shooting method on a parallel computer for solving a variety of optimal control guidance problems is studied. Several examples are considered to demonstrate that a speedup of nearly 7 to 1 is achieved with the use of 16 processors. It is suggested that further improvements in performance can be achieved by parallelizing in the state domain. EI

A95-88178
DESIGN OF AN EFFECTIVE CONTROLLER VIA DISTURBANCE ACCOMMODATING LEFT EIGENSTRUCTURE ASSIGNMENT
JAE WEON CHOI Seoul Natl Univ, Seoul, Korea, Republic of, JANG GYU LEE, YOUDAN KIM, and TAESAM KANG Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 18, no. 2 March-April 1995 p. 347-354 refs
(BTN-95-EIX95282706663) Copyright

An effective and disturbance suppressible controller can be obtained by assigning the left eigenstructure (eigen-values/left eigenvectors) of a system. To design such a controller, both the controllability and disturbance suppressibility should be considered simultaneously. The controllability of the system may be degraded if the left eigenstructure is chosen only to suppress the disturbance and vice versa. In this paper, a modal disturbance suppressibility measure is proposed that indicates the degree of the system's disturbance suppression performance, and a simple general left eigenstructure assignment scheme, considering both the proposed modal disturbance suppressibility measure and an improved version of a modal controllability measure, is suggested. The biorthogonality condition between modal matrices is utilized to develop the scheme. The proposed left eigenstructure assignment scheme makes it possible to achieve the desired left eigenstructure exactly if the desired left eigenvectors reside in the achievable subspace. In case the desired left eigenvectors do not reside in the achievable subspace, the left eigenvectors are assigned to the best possible set of eigenvectors in the least square sense, guaranteeing the desired eigenvalues to be achieved exactly. The proposed scheme is applied to a lateral flight control system design of an L-1011 aircraft model with wind disturbances. Author (EI)

A95-88895* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN INTRODUCTION TO GENERALIZED FUNCTIONS WITH SOME APPLICATIONS IN AERODYNAMICS AND AEROACOUSTICS
F. FARASSAT NASA Langley, US *In* Symposium on Aerodynamics & Aeroacoustics, Tucson, AZ, March 1-2, 1993. A95-88892 Singapore World Scientific Pub. Co. Pte. Ltd. (Advanced Series on Fluid Mechanics) 1994 p. 49-118 See also N94-34393
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In this paper, we start with the definition of generalized functions as continuous linear functionals on the space of infinitely differentiable functions with compact support. The concept of generalization differentiation is introduced next. This is the most important concept in generalized function theory and the applications we present utilize mainly this concept. First, some of the results of classical analysis, such as Leibniz rule of differentiation under the integral sign and the divergence theorem, are derived using the generalized function theory. It is shown that the divergence theorem remains valid for discontinuous vector fields provided that the derivatives are all viewed as generalized derivatives. This implies that all conservation laws of fluid mechanics are valid as they stand for discontinuous fields with all derivatives treated as generalized deriatives. Once these derivatives are written as ordinary derivatives and jumps in the field parameters across discontinuities, the jump conditions can be easily found. For example, the unsteady shock jump conditions can be derived from mass and momentum conservation laws. By using a generalized function theory, this derivative becomes trivial. Other applications of the generalized function theory in aerodynamics discussed in this paper are derivation of general transport theorems for deriving governing equations of fluid mechanics, the interpretation of finite part of divergent integrals, derivation of Oswatiitsch integral equation of transonic flow, and analysis of velocity field discontinuities as sources of vorticity. Applications in aeroacoustics presented here include the derivation of the Kirchoff formula for moving surfaces,the noise from moving surfaces, and shock noise source strength based on the Ffowcs Williams-Hawkings equation. Author (Herner)

A95-89221
FATIGUE LIFE ESTIMATION PROGRAM FOR PART 23 AIRPLANES, 'AFS.FOR'
SURINDER K. KAUL (ISSN 0148-7191) 20 May 1993 5 p. SAE, General, Corporate, & Regional Aviation Meeting & Exposition, Wichita, Kansas, May 18-20, 1993
(SAE PAPER 931249; HTN-95-B0277) Copyright

The purpose of this paper is to introduce to the general aviation industry a computer program which estimates the safe fatigue life of any Federal Aviation Regulation (FAR) Part 23 airplane. The algorithm uses the methodology (Miner's Linear Cumulative Damage Theory) and the various data presented in the Federal Aviation Administration (FAA) Report No. AFS-120-73-2, dated May 1973. The program is written in FORTRAN 77 language and is executable on a desk top personal computer. The program prompts the user for the input data needed and provides a variety of options for its intended use. The program is envisaged to be released through issuance of a FAA report, which will contain the appropriate comments, instructions, warnings and limitations.
Author (revised by Herner)

A95-90629
AIAA COMPUTING IN AEROSPACE 10, SAN ANTONIO, TX, MARCH 28-30, 1995
Washington, DC American Institute of Aeronautics and Astronautics 1995 711 p.
(ISBN 1-56347-119-1; HTN-95-92710) Copyright

A conference covered a wide range of topics related to the use of computers and computer software in the many branches of aerospace engineering. Specific areas covered included: space flight operations, satellite control, ground systems, computer hardware, computer software, human-computer interactions, artificial intelligence, avionics, computer tool development, aerospace computer systems, and computer tools. For individual titles, see A95-90630 through A95-90707. Herner

A95-90631
ANALYZING FAULT TOLERANCE USING DREDD
STACY A. DOYLE Duke University, Durham, NC, US and JOANNE BECHTA DUGAN University of Virginia, Charlottesville, VA, US *In* AIAA Computing in Aerospace 10, San Antonio, TX, March 28-30, 1995. A95-90629 Washington, DC American Institute of Aeronautics and Astronautics 1995 p. 9-19
(AIAA PAPER 95-0952) Copyright

Combinatorial models, such as fault trees, digraphs and reliability block diagrams, usually use cutset-based techniques for quantitative analysis. Recent research has suggested that the Binary Decision Diagram (BDD) offers an efficient solution alternative. However, combinatorial models by themselves are not sufficient for the analysis of fault tolerant systems unless augmented by a coverage model, which assesses the effectiveness of the recovery mechanisms incorporated for fault tolerance. In this paper, we describe the DREDD algorithm (Dependability and Risk Evaluation using Decision Diagrams), which effectively combines the BDD solution method for a combinatorial model with the solution of a coverage model. Three example fault tolerant systems are analyzed using DREDD. Author (Herner)

A95-90656* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PARALLEL CFD DESIGN ON NETWORK-BASED COMPUTER
SAMSON CHEUNG NASA. Ames Research Center, Mountain View, CA, US *In* AIAA Computing in Aerospace 10, San Antonio, TX, March 28-30, 1995. A95-90629 Washington, DC American Institute of Aeronautics and Astronautics 1995 p. 224-232

(AIAA PAPER 95-0984) Copyright

Combining multiple engineering workstations into a network-based heterogeneous parallel computer allows application of aerodynamic optimization with advanced computational fluid dynamics codes, which can be computationally expensive on mainframe supercomputers. This paper introduces a nonlinear quasi-Newton optimizer designed for this network-based heterogeneous parallel computing environment utilizing a software called Parallel Virtual Machine. This paper will introduce the methodology behind coupling a Parabolized Navier-Stokes flow solver to the nonlinear optimizer. This parallel optimization package is applied to reduce the wave drag of a body of revolution and a wing/body configuration with results of 5% to 6% drag reduction. Author (Herner)

A95-90678

DEPENDABILITY ISSUES IN THE REUSE OF STANDARD COMPONENTS IN OPEN ARCHITECTURES

C. WALTER, N. SURI, and T. MONAGHAN *In* AIAA Computing in Aerospace 10, San Antonio, TX, March 28-30, 1995. A95-90629 Washington, DC American Institute of Aeronautics and Astronautics 1995 p. 443-453
(Contract(s)/Grant(s): N62269-94-C-1267)
(AIAA PAPER 95-1006) Copyright

This paper presents a discussion of the dependability issues related to the design of mission critical systems which utilize standards based elements. A system level perspective is taken in the analysis which examines the collective operation of system elements and the impact of dependability. The implications of frameworks, fault models, and fault containment properties are discussed. An approach for dependable system design is proposed which incorporates the evaluations of various standards. A technique based on the use of option trees identifies the desired design space for which different design candidates can be proposed. A set of filters derived from system requirements are used to prune the option trees. Since our focus is primarily related to dependability aspects, the selection of filters is related to attributes affecting reliability and fault tolerance. Author (Herner)

A95-90683

A REUSE FRAMEWORK FOR SOFTWARE FAULT TOLERANCE

K. S. TSO SoHaR Incorporated, Beverly Hills, CA, US, E. H. SHOKRI SoHaR Incorporated, Beverly Hills, CA, US, A. T. TAI SoHaR Incorporated, Beverly Hills, CA, US, and R. J. DZIEGIEL, JR. USAF Rome Laboratory, Griffiss AFB, NY, US *In* AIAA Computing in Aerospace 10, San Antonio, TX, March 28-30, 1995. A95-90629 Washington, DC American Institute of Aeronautics and Astronautics 1995 p. 490-500
(Contract(s)/Grant(s): F30602-94-C-0013)
(AIAA PAPER 95-1012) Copyright

Software errors have become the major source of failures in complex systems. The current software engineering practice to achieve reliable software is to avoid errors during design and implementation and to remove committed errors through extensive testing. Although quite effective, experience has shown that it is insufficient to ensure the degree of correctness required by critical applications such as avionics control. Software fault tolerance (SWFT), which enhances the system's ability to tolerate the errors that survived during the testing phase, has been proposed as an additional measure to achieve ultra-high dependability. Although first introduced nearly two decades ago, software fault tolerance is not widely used partly due to its difficulty in implementation. An effort to identify components of SWFT schemes and to develop a framework of the desirable components for reuse will help wide utilization of software fault tolerance. This paper details the process of identifying reusable SWFT components as results of an in-depth domain analysis. The paper also discusses the design and implementation of a prototype SWFT scheme under the developed framework. Author (Herner)

A95-90688* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

A COMPUTATIONAL ENVIRONMENT FOR EXHAUST NOZZLE DESIGN

ANDREW GELSEY Rutgers University, New Brunswick, NJ, US and DON SMITH Rutgers University, New Brunswick, NJ, US *In* AIAA Computing in Aerospace 10, San Antonio, TX, March 28-30, 1995. A95-90629 Washington, DC American Institute of Aeronautics and Astronautics 1995 p. 531-539
(Contract(s)/Grant(s): NAG2-817; ARPA-DAST 63-93-C-0064)
(AIAA PAPER 95-1016) Copyright

The Nozzle Design Associate (NDA) is a computational environment for the design of jet engine exhaust nozzles for supersonic aircraft. NDA may be used either to design new aircraft or to design new nozzles that adapt existing aircraft so they may be reutilized for new missions. NDA was developed in a collaboration between computer scientists at Rutgers University and exhaust nozzle designers at General Electric (GE) Aircraft Engines and General Electric Corporate Research and Development. The NDA project has two principal goals: to provide a useful engineering tool for exhaust nozzle design, and to explore fundamental research issues that arise in the application of automated design optimization methods to realistic engineering problems. Author (Herner)

A95-90693

THE ADAGE AVIONICS REFERENCE ARCHITECTURE

DON BATORY University of Texas, Austin, TX, US, LOU COGLIANESE Loral Federal Systems, Owego, NY, US, STEVE SHAFER Loral Federal Systems, Owego, NY, US, and WILL TRACZ Loral Federal Systems, Owego, NY, US *In* AIAA Computing in Aerospace 10, San Antonio, TX, March 28-30, 1995. A95-90629 Washington, DC American Institute of Aeronautics and Astronautics 1995 p. 575-583
(Contract(s)/Grant(s): F33615-91-C-1788)
(AIAA PAPER 95-1021) Copyright

ADAGE is a project to define and build a domain-specific software architecture (DSSA) environment for avionics. A central concept of ADAGE is the use of generators to implement scalable, component-based models of avionics software. In this paper, we review the ADAGE model (or reference architecture) of avionics software and describe techniques for avionics software synthesis. Author (Herner)

A95-90703

ACCELERATED APPLICATION DEVELOPMENT FOR FLIGHT SOFTWARE

CATHY VEZZETTI *In* AIAA Computing in Aerospace 10, San Antonio, TX, March 28-30, 1995. A95-90629 Washington, DC American Institute of Aeronautics and Astronautics 1995 p. 664-672
(AIAA PAPER 95-1031) Copyright

In order to meet the customer need for 'faster, better, cheaper' flight software, a new development method and process were required for the DC-X re-usable rocket demonstrator. The common environment for algorithm design, simulation, code generation and real time testing kept the designer in the process throughout the development cycle. In the common environment the designer was able to respond quickly to requirements changes, while maintaining traceability from requirements to design and code, and ensuring configuration management. Author (Herner)

N95-28734*# United Technologies Research Center, East Hartford, CT.

AUTOMATIC BLOCKING FOR COMPLEX THREE-DIMENSIONAL CONFIGURATIONS

JOHN F. DANNENHOFFER, III *In* NASA. Lewis Research Center, Surface Modeling, Grid Generation, and Related Issues in Computational Fluid Dynamic (CFD) Solutions p 123-142 Mar. 1995
Avail: CASI HC A03/MF A10

A new blocking technique for complex three-dimensional configurations is described. This new technique is based upon the concept of an abstraction, or squared-up representation, of the configuration and the associated grid. By allowing the user to describe blocking requirements in natural terms (such as 'wrap a grid around this leading edge' or 'make all grid lines emanating from this wall orthogonal to it'), users can quickly generate complex grids around complex configurations, while still maintaining a high level of control where desired. An added advantage of the abstraction concept is that once a blocking is defined for a class of configurations, it can be automatically applied to other configurations of the same class, making the new technique particularly well suited for the parametric variations which typically occur during design processes. Grids have been generated for a variety of real-world, two- and three-dimensional configurations. In all cases, the time required to generate the grid, given just an electronic form of the configuration, was at most a few days. Hence with this new technique, the generation of a block-structured grid is only slightly more expensive than the generation of an unstructured grid for the same configuration. Author

N95-28745*# MDA Engineering, Inc., Arlington, TX.
THREE-DIMENSIONAL HYBRID GRID GENERATION USING ADVANCING FRONT TECHNIQUES
JOHN P. STEINBRENNER and RALPH W. NOACK *In* NASA. Lewis Research Center, Surface Modeling, Grid Generation, and Related Issues in Computational Fluid Dynamic (CFD) Solutions p 333-356 Mar. 1995
(Contract(s)/Grant(s): F08630-93-C-0074)
Avail: CASI HC A03/MF A10

A new 3-dimensional hybrid grid generation technique has been developed, based on ideas of advancing fronts for both structured and unstructured grids. In this approach, structured grids are first generate independently around individual components of the geometry. Fronts are initialized on these structure grids, and advanced outward so that new cells are extracted directly from the structured grids. Employing typical advancing front techniques, cells are rejected if they intersect the existing front or fail other criteria When no more viable structured cells exist further cells are advanced in an unstructured manner to close off the overall domain, resulting in a grid of 'hybrid' form. There are two primary advantages to the hybrid formulation. First, generating blocks with limited regard to topology eliminates the bottleneck encountered when a multiple block system is used to fully encapsulate a domain. Individual blocks may be generated free of external constraints, which will significantly reduce the generation time. Secondly, grid points near the body (presumably with high aspect ratio) will still maintain a structured (non-triangular or tetrahedral) character, thereby maximizing grid quality and solution accuracy near the surface. Author

N95-28763*# Computer Sciences Corp., Hampton, VA.
A GRID GENERATION SYSTEM FOR MULTI-DISCIPLINARY DESIGN OPTIMIZATION
WILLIAM T. JONES and JAMSHID SAMAREH-ABOLHASSANI *In* NASA. Lewis Research Center, Surface Modeling, Grid Generation, and Related Issues in Computational Fluid Dynamic (CFD) Solutions p 657-667 Mar. 1995
Avail: CASI HC A03/MF A10

A general multi-block three-dimensional volume grid generator is presented which is suitable for Multi-Disciplinary Design Optimization. The code is timely, robust, highly automated, and written in ANSI 'C' for platform independence. Algebraic techniques are used to generate and/or modify block face and volume grids to reflect geometric changes resulting from design optimization. Volume grids are generated/modified in a batch environment and controlled via an ASCII user input deck. This allows the code to be incorporated directly into the design loop. Generated volume grids are presented for a High Speed Civil Transport (HSCT) Wing/Body geometry as well a complex HSCT configuration including horizontal and vertical tails, engine nacelles and pylons, and canard surfaces. Author

N95-28764*# Washington Univ., Seattle, WA. Dept. of Aeronautics and Astronautics.
AUTOMATIC MULTI-BLOCK GRID GENERATION FOR HIGH-LIFT CONFIGURATION WINGS
BYOUNGSOO KIM and SCOTT EBERHARDT *In* NASA. Lewis Research Center, Surface Modeling, Grid Generation, and Related Issues in Computational Fluid Dynamic (CFD) Solutions p 671-688 Mar. 1995 Sponsored by NASA. Ames Research Center
Avail: CASI HC A03/MF A10

A new method for automatic multi-block grid generation is described. The method combines the Modified Advancing Front Method as a Predictor with an elliptic scheme as a corrector. It advances a collection of cells by one cell height in the outward direction using Modified Advancing Front Method, and then corrects newly-obtained cell positions by solving elliptic equations. This predictor-corrector type scheme is repeatedly applied until the field of interest is filled with hexahedral grid cells. Given the configuration surface grid, the scheme produces block layouts as well as grid cells with overall smoothness as its output. The present method saves human-time and reduces the burden on the user in generating grids for general 3-D configurations. It was used to generate multi-block grids for wings in their high-lift configuration. Author

N95-28807*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
IMPACT OF ADA AND OBJECT-ORIENTED DESIGN IN THE FLIGHT DYNAMICS DIVISION AT GODDARD SPACE FLIGHT CENTER
SHARON WALIGORA (Computer Sciences Corp., Greenbelt, MD.), JOHN BAILEY (Software Metrics, Inc., Haymarket, VA.), and MIKE STARK Mar. 1995 92 p
(NASA-CR-189412; SEL-95-001; NAS 1.26:189412) Avail: CASI HC A05/MF A01

The Software Engineering Laboratory (SEL) is an organization sponsored by NASA/GSFC and created to investigate the effectiveness of software engineering technologies when applied to the development of applications software. The goals of the SEL are (1) to understand the software development process in the GSFC environment; (2) to measure the effects of various methodologies, tools, and models on this process; and (3) to identify and then to apply successful development practices. The activities, findings, and recommendations of the SEL are recorded in the Software Engineering Laboratory Series, a continuing series of reports that includes this document. Author

N95-29074# Stanford Univ., CA.
A STUDY OF FLUID PROBLEMS REQUIRING A DIRECT PARTICLE SIMULATION Final Report, 1 Apr. 1993 - 30 Sep. 1994
DONALD BAGANOFF 28 Nov. 1994 30 p
(Contract(s)/Grant(s): F49620-93-1-0143)
(AD-A290212; AFOSR-95-0055TR) Avail: CASI HC A03/MF A01

The principal objective was to make use of a parallel computer code recently developed by our group, for Bird's direct simulation Monte Carlo (DSMC) method, and to gain experience in simulating various rarefied three-dimensional flows about bodies having reasonably complex geometries, for example, bodies based on geometries associated with current practical applications. DTIC

N95-29251 Purdue Univ., West Lafayette, IN.
LINEAR AND NONLINEAR DISCRETE-TIME STATE-SPACE MODELING OF DYNAMIC SYSTEMS FOR CONTROL APPLICATIONS Ph.D. Thesis
EDUARDO ALVES RODRIGUES 1993 170 p
Avail: Univ. Microfilms Order No. DA9420895

This research proposes a methodology to model a class of nonlinear dynamic systems, known as linear-analytic systems, by discrete-time state-space models. The method is based on a series of deterministic simulations of the differential equations of motion using well designed step-like input functions. The simulation results are processed to generate a vector series characterizing the selected discrete-time state-space model. A realizations algorithm developed in this research is then applied to the computed vector series in order to obtain the matrices describing the state-space model. It is shown that the vector series obtained from the simulation results are discrete-time triangular Volterra kernels. Therefore, the designed simulations can be viewed as a new method to identify discrete-time Volterra kernels. Nevertheless, the emphasis here is in generating state-space models, since they are more attractive for design and analysis of control systems than the Volterra system representation. The novelty of the methodology being proposed is the fact it does not require continuous-time state-space modeling of the system as an intermediate step in the process: it goes from nonlinear differential equations directly to discrete-time state-space models. Such a philosophy seems attractive in the modeling of dynamic systems immersed in air flow fields, with aerodynamic forces being computed through the use of CFD codes. The main disadvantage in the methodology is that the number of simulations grows exponentially with the discrete-time model order, a direct consequence of the number of parameters needed to be fed into the nonlinear realizations algorithm. Nevertheless, since each simulation is independent of the others, the simulations could be carried out by parallel processing in modern computers, reducing the total time necessary to obtain the simulations by a factor equal to the number of processors available in the parallel processing. Applications are first made to the modeling of simple dynamic systems containing nonlinearities caused by the presence of trigonometric functions on the differential equations of motion. Subsequently, the methodology is applied to an aeroservoelastic system containing nonlinear phenomena caused by transonic unsteady aerodynamics.

Dissert. Abstr.

N95-29454*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

TRANSPORT DELAYS ASSOCIATED WITH NASA LANGLEY FLIGHT SIMULATION FACILITY

R. MARSHALL SMITH, VICTORIA I. CHUNG, and DEBBIE MARTINEZ Feb. 1995 10 p

(Contract(s)/Grant(s): RTOP 505-90-53-02)

(NASA-TM-110150; NAS 1.15:110150) Avail: CASI HC A02/MF A01

This paper describes the transport delays associated with flight simulation programs currently operating at the NASA Langley Research Center (LaRC). Formulas are presented for calculating a rough estimate of the transport delay for a particular simulation. Various simulation programs that used the Flight Simulation Facility at LaRC, during the period of October 1993 to March 1994, were tested to determine the transport delays associated with the simulation program and any associated hardware. Several simulators were tested, including the Differential Maneuvering Simulator (DMS), the Visual Motion Simulator (VMS), and the Transport System Research Vehicle (TSRV). Author

N95-29618# Vaerloese Air Base, Vaerloese (Denmark). Medical Squadron 590.

FLYING AMBULANCES: THE APPROACH OF A SMALL AIR FORCE TO LONG DISTANCE AEROMEDICAL EVACUATION OF CRITICALLY INJURED PATIENTS

J. NYBO NIELSEN, S. LYDUCH, and F. K. LARSEN *In* AGARD, Recent Issues and Advances in Aeromedical Evacuation (MEDEVAC) 3 p Feb. 1995

Copyright Avail: CASI HC A01/MF A02

The Danish Air Force has developed a system for Aeromedical Evacuation of injured soldiers, based on flying ambulances inside a C-130. The ambulances function as mobile intensive care units, and provide a quiet, well lit and air-conditioned environment for observation and treatment of the patients. The system has a limited capacity, but it has so far proved sufficient to support the Danish participation in the UN-peacekeeping missions in the former Yugoslavia. A number of missions have been successfully carried out, three of them with two ambulances in the C-130. The system has the added advantage of providing door to door transport, without the need for moving the patient from ambulance to aircraft, and again from the aircraft to another ambulance on arrival in Denmark. To increase the capacity in the future, a system using specially equipped containers to be carried in the cargo bay of a C-130 is under consideration, and 2 such containers will probably be ordered this year. For the future AIREVAC support of a Danish battalion as part of NATO's Rapid Reaction Forces, we suggest a system based on chartered Boeing 737's or similar aircraft, and reservist personnel which should be identified and trained for the mission. The readiness of the system should be insured through planning, including contracts with airlines and personnel, training of medical personnel and procurement of stretcher support system and medical supplies. Author

N95-29619# Department of the Air Force, Brooks AFB, TX. Nurse Corps.

CIVIL RESERVE AIR FLEET-AEROMEDICAL EVACUATION SHIPSET (CRAF-AESS)

CANDY JEAN NISTLER *In* AGARD, Recent Issues and Advances in Aeromedical Evacuation (MEDEVAC) 2 p Feb. 1995

Copyright Avail: CASI HC A01/MF A02

In 1985, the USAF/SG, AMC/SG, and CINCAMC agreed in time of war there would not be enough C-141's and C-9's that could be dedicated to Aeromedical Evacuation (AE). It was decided to design a kit that could re-configure Civil Reserve Air Fleet aircraft, specifically the Boeing 767, into AE aircraft to perform strategic and CONUS missions. A formal acquisition program was planned and executed by the Human Systems Program Office, Brooks AFB, TX, to design, develop, and produce the conversion kit for the Boeing 767. Developmental and Operational Test Evaluation Flights were flown in March 1991. The FAA issued flying certificates for two configurations of the Boeing 767 conversion kit; one to carry 111 litter patients and one to carry 87 litter patients. The CRAF-AESS has three subsystems. The Patient Transport Subsystem (PTS) consists of the litter stanchions and litter support arms for up to 111 litter patients. The Medical Oxygen Subsystem (MOS) consists of six 75 liter Dewars, which supply therapeutic oxygen outlets located at each potential litter position. The Aeromedical Operations Subsystem (AOS) consists of six 35 amp electrical converters to convert aircraft power to regular hospital current for medical equipment use. Electrical outlets are located at each potential litter position. This subsystem also includes two nurse workstations and seats. The airlines signed a contract with the USAF to be a CRAF-AESS supporter. Civilian airline pilots will fly the CRAF-AESS aircraft, airline flight attendants will be in charge of emergency egress, and the Systems Program Office is currently in full production for 44 shipsets. There are 17 complete shipsets delivered to date. CRAF-AESS will expand the USAF AE capabilities during war and allows medical personnel to provide excellent medical care. Author

N95-29620# Army Aeromedical Research Lab., Fort Rucker, AL. Aircrew Protection Div.

FIRST MEDICAL TEST OF THE UH-60Q AND EQUIPMENT FOR USE IN US ARMY MEDEVAC HELICOPTERS

J. E. BRUCKART, J. R. LICINA, and M. D. QUATTLEBAUM *In* AGARD, Recent Issues and Advances in Aeromedical Evacuation (MEDEVAC) 5 p Feb. 1995

Copyright Avail: CASI HC A01/MF A02

The U.S. Army operates helicopters worldwide, including over 500 designated for medical evacuation (MEDEVAC). Advanced avionics and a commercial medical interior have been installed in a Black Hawk helicopter, designated the UH-60Q. MEDEVAC aircraft also carry commercial medical devices that can fail from stresses of in-flight use or interfere with critical rotary-wing aircraft systems. The U.S. Army Aeromedical Research Laboratory (USAARL) performed the first flight tests evaluating the medical interior in the UH-60Q and tested commercial medical devices to determine their compatibility with MEDEVAC aircraft. Flight tests in the UH-60Q validated the enhanced capability provided by the new avionics systems, external rescue hoist, oxygen generator, built-in suction, litter lifts, and improved crew seating. The new litter lift system provided inadequate vertical clearance and several components of the restraint hardware were not sufficiently durable. From January 1989 to January 1994, 40 medical devices, including monitor/defibrillators, infusion pumps, vital sign monitors, ventilators, oxygen generators, and infant transport incubators, were tested under extreme conditions of temperature, humidity, altitude, and vibration (MIL-STD 810). Electromagnetic emissions and susceptibility were measured (MIL-STD 461 & 462). Thirty-two percent of the medical devices failed at least one environmental test and 92 percent of the devices failed to meet electromagnetic interference standards. Eighteen percent of the commercial medical devices were judged unsuitable for use in the UH-60 MEDEVAC helicopter. Testing is critical to discover the ability of a new aircraft system or medical device to perform in the harsh rotary-wing MEDEVAC environment. Failure of a device or interference with aircraft systems can result in loss of a patient or aircrew. Author

N95-29622# Department of the Air Force, Brooks AFB, TX. Armstrong Lab.
INTERNATIONAL ACCESS TO AEROMEDICAL EVACUATION MEDICAL EQUIPMENT ASSESSMENT DATA
JACQUELINE HALE *In* AGARD, Recent Issues and Advances in Aeromedical Evacuation (MEDEVAC) 3 p Feb. 1995
Copyright Avail: CASI HC A01/MF A02

Aeromedical evacuation medical equipment development using evaluation and often times modification by the manufacturer to achieve compatibility in the airborne environment began over 25 years ago at Brooks AFB in support of Military Airlift Commands (now Air Mobility Command) medical evacuation mission. This approach was adopted because sometimes standard research and development methods were not responsive to Command requirements. In the course of those years simple items such as securing devices to those as complicated as an Extracorporeal Membrane Oxygenation System have been extensively evaluated using a battery of tests to verify adapt ability to altitude and compatibility with aircraft systems. Because technology in aircraft systems and in medical equipment has advanced, so has the importance of testing for situational compatibility. Medical devices may produce electromagnetic interference with aircraft navigation or communication systems and aircraft systems can interfere with the operation of medical devices. Results of tests conducted at Armstrong Laboratory Brooks AFB are published as individual detailed Technical Reports and later compiled into a comprehensive document entitled 'Status Report on Medical Material Items Tested And Evaluated For Use In The USAF Aeromedical Evacuation System'. This publication was available for public release and met customer access needs of the day. However, with the advent of independent air ambulance services and increase in countries actively engaged in aeromedical evacuation, a need to better communicate results of testing emerged. Researchers at Armstrong Laboratory developed a database program for rapid dissemination of medical equipment airworthiness evaluation results and are exploring electronic delivery avenues to meet the need for worldwide accessibility. Author

N95-29644# Norfolk State Univ., VA.
PROCEEDINGS OF THE 12TH ANNUAL NATIONAL CONFERENCE ON ADA TECHNOLOGY
24 Mar. 1994 349 p Conference held in Williamsburg, VA, 21-24 Mar. 1994; sponsored by ANCOST, Inc.
(Contract(s)/Grant(s): F33615-91-C-1758)
(AD-A290693) Avail: CASI HC A15/MF A03

Partial contents include the following: OOP/Groupware; Software Engineering; Comparison of Design Diversity Techniques for Fault Tolerant Ada Software Development; An Overview of the Ada Semantic Interface Specification; Ada's Role in Preventing Data Corruption; Theory Vs. Reality in a large Avionics Software Project; Metrics; Ada Language Issues; Education - The Undergraduate Student and Ada; Object Oriented Development; and Integrating Ada into Reuseable Software. DTIC

N95-30248* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TELEPRESENCE MEDIA RESOURCE TAPE (Videotape)
31 Jan. 1992 Sponsored by NASA, Washington Videotape: 9 min. playing time, in color, with sound
(NASA-TM-110648; NASA-AAV-1387; NONP-NASA-VT-95-57872)
Avail: CASI VHS A02/BETA A22

Dr. Michael McGreevey (NASA's Ames Research Center) explains what virtual reality is and how NASA uses this concept. Computer animation of different planets using virtual reality is shown. One Ames research tool, the Virtual Wind Tunnel allows air flow to be studied inside the tunnel from any conceivable location. Dr. Carol Stoker (NASA's Ames Research Center) comments on Telepresence, one form of virtual reality. CASI

N95-30353*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
PRESSURE UPDATING METHODS FOR THE STEADY-STATE FLUID EQUATIONS
A. FITERMAN (Weizmann Inst. of Science, Rehovot, Israel.), E. TURKEL (Tel-Aviv Univ., Ramat-Aviv, Tel-Aviv, Israel.), and V. VATSA May 1995 16 p
(Contract(s)/Grant(s): NAS1-19480; RTOP 505-90-52-01)
(NASA-CR-198163; NAS 1.26:198163; ICASE-95-40) Avail: CASI HC A03/MF A01

We consider the steady state equations for a compressible fluid. Since we wish to solve for a range of speeds we must consider the equations in conservation form. For transonic speeds these equations are of mixed type. Hence, the usual approach is to add time derivatives to the steady state equations and then march these equations in time. One then adds a time derivative of the density to the continuity equation, a derivative of the momentum to the momentum equation and a derivative of the total energy to the energy equation. This choice is dictated by the time consistent equations. However, since we are only interested in the steady state this is not necessary. Thus we shall consider the possibility of adding a time derivative of the pressure to the continuity equation and similar modifications for the energy equation. This can then be generalized to adding combinations of time derivatives to each equation since these vanish in the steady state. When using acceleration techniques such as residual smoothing, multigrid, etc. these are applied to the pressure rather than the density. Hence, the code duplicates the behavior of the incompressible equations for low speeds.
Author

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A95-86859
EXPERIMENTAL INVESTIGATION OF THE SOURCES OF PROPELLER NOISE DUE TO THE INGESTION OF TURBULENCE AT LOW SPEEDS
D. F. SCHARPF Boeing Commercial Airplane Group, Seattle, WA, United States and T. J. MUELLER Experiments in Fluids (ISSN 0723-4864) vol. 18, no. 4 February 1995 p. 277-287
(BTN-95-EIX95262697042) Copyright

Noise radiation from a four bladed, 10 in. diameter propeller operating in air at a rotational speed of 3000 RPM and a freestream velocity of 33 ft/s was experimentally analyzed using hot-wire and microphone measurements in an anechoic wind tunnel. Turbulence levels from 0.2 to 5.5% at the propeller location were generated by square-mesh grids upstream of the propeller. Autobicoherence measurements behind the blade trailing edges near the hub and tip showed regions of high phase-coherence between the blade-passage harmonics and the broadband frequencies. Inflow turbulence reduced this coherence. By relating the fluctuation velocities in the propeller wake to the unsteady blade forces, the primary regions of tonal noise generation have been identified as the hub and tip regions, while the midspan has been identified as a region responsible for broadband noise generation. These measurements were complimented by cross-spectra between the propeller wake-flow and the measured sound. The effect of turbulence on the radiated noise level showed an overall increase of 2 dB in the broadband levels for every 1% increase in turbulence. This effect varied for different frequency bands in the acoustic spectrum. Author (EI)

A95-87571* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ACTIVE CONTROL OF FAN NOISE FROM A TURBOFAN ENGINE

RUSSELL H. THOMAS Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, US, RICARDO A. BURDISSO Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, US, CHRISTOPHER R. FULLER Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, US, and WALTER F. O'BRIEN Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 1 January 1994 p. 23-30 Research sponsored by the Applied Acoustics Branch and the Mission Analysis Branch
(HTN-95-61198) Copyright

A three-channel active control system is applied to an operational turbofan engine to reduce tonal noise produced by both the fan and the high-pressure compressor. The control approach is the feedforward filtered-x least-mean-square algorithm implemented on a digital signal processing board. Reference transducers mounted on the engine case provide blade passing and harmonics frequency information to the controller. Error information is provided by large area microphones placed in the acoustic far field. To minimize the error signal, the controller actuates loudspeakers mounted on the inlet to produce destructive interference. The sound pressure level of the fundamental tone of the fan was reduced using the three-channel controller by up to 16 dB over a +/- 30-deg angle about the engine axis. A single-channel controller could produce reduction over a +/- 15-deg angle. The experimental results show the control to be robust. Outside of the areas contolled, the levels of the tone actually increased due to the generation of radial modes by the control sources. Simultaneous control of two tones is achieved with parallel controllers. The fundamental and the first harmonic tones of the fan were controlled simultaneously with reductions of 12 and 5 dBA, respectively, measured on the engine axis. Simultaneous control was also demonstrated for the fan fundamental and the high-pressure compressor fundamental tones. Author (Herner)

A95-88459

THE PROPAGATION OF SOUND FROM AN ARBITRARILY ORIENTED DIPOLE OVER A FINITE IMPEDANCE PLANE

Z. HU Purdue Univ., West Lafayette, IN, US and J. S. BOLTON Purdue Univ., West Lafayette, IN, US *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 147-152
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Many theories are available for predicting outdoor sound propagation in terms of sound radiation from a point monopole in the presence of a finite impedance plane. However, not all practical sources are monopolar in character. In this paper, the theory of a two-dimensional Hankel transform technique for predicting sound propagation over an impedance plane is described and its predictions are compared with model-scale measurements. The technique presented here now makes it possible to predict the sound propagation from a higher order source, such as an arbitrarily oriented dipole; it may thus prove useful for predicting sound propagation from aerodynamic noise sources, such as propellers or wind turbines, over outdoor surfaces. Author (Herner)

A95-88462

MONITORING NOISE FROM AIRCRAFT OPERATIONS IN THE VICINITY OF AIRPORTS

KENNETH MCK. ELDRED Ken Eldred Engineering, Concord, MA, US *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 865-870
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This paper presents an overview of a proposed Society of Automotive Engineers Aerospace Recommended Practice (ARP4721) with this title. The ARP is intended to provide engineering methods for measuring the noise from aircraft operations in the vicinity of airports for a variety of potential users and purposes. It uses the A-weighted Sound Level (Slow) and quantities derived from its time history as the principal descriptor of aircraft noise. It represents an evolutionary growth from the airport noise monitoring experience over the past three decades. It is intended to cover both unattended multi-channel noise measurement systems used for routine monitoring and attended systems used for special monitoring or for other measurement purposes. It contains recommended methods for the acquisition of non-acoustical data and requirements for systems that acquire acoustical data and their processing. It provides information on temporal and spatial sampling with respect to sampling design and errors, and discusses several applications for its use in monitoring. Author (Herner)

A95-88463

NORDIC STANDARDS FOR MEASUREMENT OF AIRCRAFT NOISE IMMISSION IN RESIDENTIAL AREAS AND NOISE REDUCTION OF DWELLINGS

CHRISTIAN SVANE Danish Acoustical Institute, Lyngby, Denmark and BIRGER PLOVSING Danish Acoustical Institute, Lyngby, Denmark *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation
(ISSN 0105-175X) 1992 p. 871-876 Copyright

Quantification by measurement of aircraft noise in residential areas and air traffic noise reduction of dwellings suffer from sensibility to the measurement technique used. Around the Copenhagen Airport (200.000 opr./year) 3.500 families have been granted from 50% to 90% of sound insulation costs by the Danish Government. Based on experience from evaluation measurements carried out by the Danish Acoustical Institute, the authors have proposed standardized measurement methods for the outdoor aircraft noise in residential areas and for the noise reduction of dwellings. In 1989 both noise measurement methods were accepted as Nordic Standards (NORDTEST ACOU 074 and 075) by Denmark, Finland, Iceland, Norway and Sweden. Author (Herner)

A95-88464

MODELING LATERAL ATTENUATION OF AIRCRAFT FLIGHT NOISE

J. D. SPEAKMAN Wright-Patt AFB, OH, US and B. F. BERRY National Physical Lab., Teddington, UK *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 877-882
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To calculate the airbase and/or airport noise exposure at any specified ground position located to the side of a flight path, a variety of noise attenuation mechanisms must be accounted for if the model is to predict levels that are in reasonable agreement with field noise measurements. For civil aircraft the lateral attenuation model developed by the Society of Automotive Engineers, Inc. A-21 Committee on Aircraft Noise is commonly used. Since it was derived mainly from measured lateral attenuation data on civil aircraft, the predicted results generally show good agreement when compared with actual measurements. However, the frequency spectra of the noise from most military aircraft is often quite different from that associated with civil transports. A series of field experiments was conducted to develop a data base of sufficient size (853 points at elevation angles aranging from 1.9 to 90 degrees) to accurately model the lateral attenuation associated with military flights near airbases and especially along Military Training Routes where the aircraft fly at low altitude (150 m or less) and at high subsonic airspeeds. Those tests confirmed the need for a different model of lateral attenuation for typical United States military versus civil aircraft flight operations. A companion paper, A Prediction Model for Noise From Low-Altitude Military Aircraft, describes recent tests performed in the United Kingdom. Two of the aircraft (F-15 and F-16) were common to the tests performed in the United States and the United Kingdom. This paper merges the 182 data points at very low elevation angles (1.3 to 6.8 degrees) from the UK tests, adds 154 more USAF data points at low to moderate elevation angles (3 to 45 degrees) and derives an improved model for lateral attenuation associated with military aircraft. Author (revised by Hemer)

A95-88465

FACTORS AFFECTING MEASURED AIRCRAFT SOUND LEVELS IN THE VICINITY OF START-OF-TAKEOFF ROLL

HORONJEFF RICHARD Harris Miller Miller & Hanson Inc., Lexington, MA, US, GREGG G. FLEMING Volpe National Transportation Systems Center, Cambridge, MA, US, EDWARD J. RICKLEY Volpe National Transportation Systems Center, Cambridge, MA, US, and THOMAS L. CONNOR Federal Aviation administration, Washington, DC, US *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 883-888

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This paper presents the findings of a recently conducted measurement and analysis program of jet transport aircraft sound levels in the vicinity of the star-of-takeoff roll. The purpose of the program was two-fold: (1) to evaluate the computational accuracy of the Federal Aviation Administration's Integrated Noise Model (INM) in the vicinity of start-of-takeoff roll with a recently updated database (INM 3.10), and (2) to provide guidance for future model improvements. Focusing on the second of these two goals, this paper examines several factors affecting Sound Exposure Levels (SELs) in the hemicircular area behind the aircraft brake release point at the start-of-takeoff. In addition to the aircraft type itself, these factors included the geometric relationship of the measurement site to the runway, the wind velocity (speed and direction), aircraft grow weight, and start-of-roll mode (static or rolling start). Author (Hemer)

A95-88466

A PREDICTION MODEL FOR NOISE FROM LOW-ALTITUDE MILITARY AIRCRAFT

B. F. BERRY National Physical Lab., Teddington, UK and J. D. SPEAKMAN Armstrong Lab., WPAFB, OH, US *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 889-894 Research sponsored by the UK Ministry of Defense

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For a number of years, the National Physical Laboratory, supported by the Ministry of Defense, has been developing AIRNOISE, a mathematical model for computing aircraft noise contours. As part of the continuous program of development of the model, we were asked to extend it to include low-altitude military operations. The objective is to predict the complete time-history of the noise of these very rapid events, thus providing information on onset rates as well as maximum levels. In order to provide high quality data with which to validate and refine the model, a special noise trial - Exercise Luce Belle - was conducted in which a number of aircraft types flew low, straight, and level, at various speeds and engined power settings. This paper first describes the noise trial and then the prediction model. The comparison of predictions with actual measurements is discussed. In particular the effects of changes in the assumptions in the model about lateral attenuation are explored. Author (Hemer)

A95-88467

METEOROLOGICAL IMPACTS ON AIRPORT NOISE PREDICTION BY THE 'INTEGRATED NOISE MODEL' APPLICATION BASED ON HAMILTONIAN RAY-TRACING PROGRAM AND MEASUREMENTS

D. G. TSOUKA Univ. of Athens, Athens, Greece and K. ABACOUMKIN Univ. of Athens, Athens, Greece *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 895-898

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The flexible Integrated Noise Model (INM) model assumes straight line noise propagation and takes into account only the main site ground temperature. Many authors have studied the strong noise dependence on meteorological parameters and the ground effects based on the Weyl-Van der Pol equation concerning only homogeneous atmosphere and linear propagation. This paper presents a methodology for the development of a new INM Lateral Attenuation algorithm based on refracted rays propagation - Hamiltonian Ray-Tracing program (HARPA) - and on a revised Weyl-Van der Pol model application. Author (Hemer)

A95-88468

AUXILIARY POWER UNIT NOISE OF BOEING B737 AND B747 AIRCRAFT

JIMMY S. W. KWAN Cathay Pacific Airways Ltd., Kowloon, Hong Kong and S. J. ERIC YANG Heriot-Watt Univ., Edinburgh, HK *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 899-902

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Most modern civil aircraft have an Auxiliary Power Unit (APU) which provides compressed air for engine starting and the air-conditioning system on ground and electrical power for aircraft use both on-ground and in-fligth. It is basically a gas turbine engine and it consists of a compressor section, a turbine section, and an accessory drive section. For Boeing B737 and B747 aircraft, the APU is located inside a compartment in the tail section of the aircraft and is completely enclosed by a sound-reduction fire-proof titanium shroud. APU noise is one of the major noise sources at many airports and is extremely important for a densely populated city such as Hong Kong. The noise from APU can affect many people, including ground crew aircraft maintenance staff, and people living in the vicinity of the airport. However, there is very little information available in the literature about APU noise. This paper describes the noise measurement method and presents the measurement results for APUs of one B747 and two B737 aircraft under both 'loaded' and 'no-load' conditions. Author (Hemer)

A95-88469

PREDICTION LEVEL OF NOISE BY A HELICOPTER

HIDEO SHIBAYAMA Shibaura Inst. of Tech., Tokyo, Japan, TAKASHI TAKAYAMA The Tokyo Metropolitan Research Inst., Tokyo, Japan, and SHIN'ITI NAKAMURA The Tokyo Metropolitan Research Inst., Tokyo, Japan *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 927-930

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This paper describes the prediction level of noise which is generated by a helicopter. The relation between noise levels and distance from the helicopter to an observing point is measured. From these measured results, acoustic power level generated by the helicopter is calculated. Noise levels can be estimated by measuring the distance from the helicopter's flight path. Prediction of the noise levels is in good agreement with measured noise levels. Author (Hemer)

A95-88470

BROADBAND NOISE CHARACTERISTICS OF A MODEL COUNTER-ROTATING SHROUDED PROPFAN

JAN BOETTCHER DLR-Deutsche Forschungsanstalt fuer Luft, Braunschweig, Germany, WERNER DOBRZYNSKI DLR-Deutsche Forschungsanstalt fuer Luft, Braunschweig, Germany, and BURKHARD GEHLHAR DLR-Deutsche Forschungsanstalt fuer Luft, Braunschweig, Germany *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 931-934

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In recent years counter-rotating propfan aeroengines were developed since they promise significant fuel savings compared to conventional fan engines. The German manufacturer MTU has developed the CRISP (Counter-Rotating Integrated Shrouded Propfan) 1:6.25-scale model engine which has been tested in the German Dutch Wind Tunnel (DNW). The present study concentrates on the broadband noise component and its relative importance to the total sound emission. While single-propeller/propfan noise emission is dominated by rotational noise, a counter-rotating propfan may constitute a significant source of broadband noise.

Author (Hemer)

A95-88471

DEVELOPMENT AND VALIDATION OF A NUMERICAL ACOUSTIC ANALYSIS PROGRAM FOR AIRCRAFT INTERIOR NOISE PREDICTION

RALPH GARCEA de Havilland Inc., Downsview, Ontario, Canada, BARRY LEIGH de Havilland Inc., Downsview, Ontario, Canada, and R. L. M. WONG de Havilland Inc., Downsview, Ontario, Canada *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 935-938

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Reduction of interior noise in propeller-driven aircraft, to levels comparable with those obtained in jet transports, has become a leading factor in the early design stages of the new generation turboprops- and may be essential if these new designs are to succeed. The need for an analytical capability to predict interior noise is accepted throughout the turboprop aircraft industry. To this end, an analytical noise prediction program, which incorporates the SYSNOISE numerical acoustic analysis software, is under development at de Havilland. The discussion contained herein looks at the development program and how it was used in a design sensitivity analysis to optimize the structural design of the aircraft cabin for the purpose of reducing interior noise levels. This report also summarizes the validation of the SYSNOISE package using numerous classical cases from the literature. Author (Hemer)

A95-88472

IN-FLIGHT INTERIOR SOUND FIELD MAPPING IN PROPELLER AIRCRAFT

H. VAN DER AUWERAER LMS Belgium BVBA, Leuven, Belgium, L. GIELEN LMS Belgium BVBA, Leuven, Belgium, and D. OTTE LMS Belgium BVBA, Leuven, Belgium *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 939-942

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Interior noise in propeller aircraft is currently an important issue in the aerospace industry. Efficient noise control measures require a thorough understanding of the in-flight response of the vibro-acoustic system, formed by fuselage, trim panels and cabin cavity, to the propeller excitation. The cabin interior noise is dominated by the lower order blade pass tones of the propellers. It is therefore important to map the acoustic sound field and the trimpanel and fuselage vibration responses at these frequencies. It is further advantageous to estimate the separated contributions of the two propellers because it allows a better understanding of the coupling between the propeller sound fields, the fuselage and the cabin cavity. It also provides a convenient means to compare different flight tests, regardless of the synchrophasor setting or stability. This paper discusses the acquisition and analysis of operating data on a fully trimmed Saab 340, a twin-engine commuter aircraft. The estimation of each propeller's contribution by means of cross-spectrum and coherence analysis techniques is further explored, in relation with signal processing issues, as windowing and leakage. Some resulting in-flight cabin cavity sound field shapes and trimpanel deformations are presented and discussed. Author (Hemer)

A95-88893

SOME ASPECTS OF THE AEROACOUSTICS OF EXTREME-SPEED JETS

JAMES LIGHTHILL University College London, London, UK *In* Symposium on Aerodynamics & Aeroacoustics, Tucson, AZ, March 1-2, 1993. A95-88892 Singapore World Scientific Pub. Co. Pte. Ltd. (Advanced Series on Fluid Mechanics) 1994 p. 3-37 See also N93-28975

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The lecture begins by sketching some of the background to contemporary jet acoustics. Then it reviews scaling laws for noise generation by low-Mach-number airflows and by turbulence convected at not so low Mach number. These laws take into account the influence of Doppler effects associated with the convection of aeroacoustic sources. Next, a uniformly valid Doppler-effect approximation exhibits the transition, with increasing Mach number of convection, from compact-source radiation at low Mach numbers to a statistical assemblage of conical shock waves radiated by eddies convected at supersonic speed. The lecture continues by describing a new dynamic theory of the nonlinear propagation of such statistically random assemblages of conical shock waves. It is shown, both by a general theoretical analysis and by an illustrative computational study, how their propagation is dominated by a characteristic bunching process. That process-associated with a tendency for shock waves that have already formed unions with other shock waves to acquire an increased proneness to form further unions-acts so as to enhance the high-frequency part of the specttrum of noise emission from jets at these high exit speeds.

Author (Hemer)

A95-89894

FAN NOISE REDUCTION FROM A SUPERSONIC INLET DURING SIMULATED AIRCRAFT APPROACH

W. E. NUCKOLLS Virginia Polytechnic Inst and State Univ, Blacksburg, VA, United States and W. F. NG Journal of Engineering for Gas Turbines and Power, Transactions of the ASME (ISSN 0742-4795) vol. 117, no. 2 April 1995 p. 237-244 refs (BTN-95-EIX95292721155) Copyright

A series of experiments was conducted to investigate the radiation of fan noise from a supersonic inlet during a simulated aircraft approach. A scaled-down model of an axisymmetric, mixed-compression, supersonic inlet (P-inlet) was used in conjunction with a 10.4 cm (4.1 in) diameter turbofan engine simulator as the noise source. The tests were conducted at an outdoor facility under static conditions. The main goal of the experiment was to reduce the forward radiating fan noise by modifying the auxiliary inlet doors. The modified doors are designed to reduce the inlet distortion to the fan face. In addition, the new door design also uses a converging flow passage in order to take advantage of the noise attenuation due to the choking effect at the auxiliary door. The simulator was tested at 60 percent design speed in an attempt to match the simulator noise source to that of a real aircraft engine on approach. Both aerodynamic and acoustic measurements were taken in the experiments. The results show that when compared to the original design, the modified auxiliary inlet doors reduced the circumferential inlet distortion to the fan face by a factor of two. The key result is that the blade passing frequency tone has been decreased by an average of 6 dB in the forward sector for the modified door design. Results from the closed auxiliary inlet door case are also presented to provide additional comparisons. Author (EI)

A95-90088* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

NOISE CONTROL IN AEROACOUSTICS; PROCEEDINGS OF THE 1993 NATIONAL CONFERENCE ON NOISE CONTROL ENGINEERING, NOISE-CON 93, WILLIAMSBURG, VA, MAY 2-5, 1993

HARVEY H. HUBBARD, editor Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 651 p.
(ISBN 0-931784-26-3; HTN-95-A1513) Copyright

In the conference over 100 papers were presented in eight sessions: (1) Emission: Noise Sources; (2) Physical Phenomena; (3) Noise ControlElements; (4) Vibration and Shock: Generation, Transmission, Isolation, and Reduction; (5) Immission: Physical Aspects of Environmental Noise; (6) Immission: Effects of Noise; (7) Analysis; and (8) Requirements. In addition, the distinguished lecture series included presentations on the High Speed Civil Transport and on research from the United Kingdom on aircraft noise effects. For individual titles, see A95-90089 through A95-90141. Herner

A95-90092

CONCEPTS FOR THE CONTROL OF ROTOR NOISE

HAROLD E. LEMONT Lemont Aircraft Corp., Ansonia, CT, US and TREVOR BURWARD-HOY Sun Microsystems, Inc., Mountain View, CA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 51-56
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Noise is an aural expression of wasted energy, e.g., for an aerodynamically-efficient rotor, less noise is created. Inherent rotor noise has qualities associated with stall or rotational velocities (tip/root vortices), translational velocity effects (hub, pylon flow separation), and combinations. Secondary factors are those associated with impact of the rotational airflow components on other blades (impulse noise), other vortices, structures, wakes, exhausts, etc. Vehicle motion compounds these into undesirable sound levels for aircraft flyby values. This paper discusses methods for modification of the tip vortex strength to reduce noise for helicopter rotors, household fans, and computer fans. Author (revised by Herner)

A95-90093* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

STUDIES OF BLADE-VORTEX INTERACTION NOISE REDUCTION BY ROTOR BLADE MODIFICATION

THOMAS F. BROOKS NASA. Langley Research Center, Hampton, VA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 57-66
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Blade-vortex interaction (BVI) noise is one of the most objectionable types of helicopter noise. This impulsive blade-slap noise can be particularly intense during low-speed landing approach and maneuvers. Over the years, a number of flight and model rotor tests have examined blade tip modification and other blade design changes to reduce this noise. Many times these tests have produced conflicting results. In the present paper, a number of these studies are reviewed in light of the current understanding of the BVI noise problem. Results from one study in particular are used to help establish the noise reduction potential and to shed light on the role of blade design. Current blade studies and some new concepts under development are also described. Author (Herner)

A95-90094

NUMERICAL AND FLIGHT MEASURED INTERIOR NOISE CHARACTERISTICS OF A TWIN-ENGINE TURBOPROP GENERAL AVIATION AIRCRAFT

F. MARULO Naples Univ., Naples, Italy, L. LECCE Naples Univ., Naples, Italy, S. DE ROSA Naples Univ., Naples, Italy, C. A. D'AMATO Partenavia Costruzioni Aeronautiche S.p.A., Naples, Italy, and G. VERDE Partenavia Costruzioni Aeronautiche S.p.A., Naples, Italy *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 67-72
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The paper presents the flight test results of an interior noise measurement campaign on a twin-engine turboprop general aviation aircraft conducted for assessing the real values inside such aircraft and for approaching the problem of its noise reduction. Simultaneously a numerical study has been performed in order to correlate the experimental and the theoretical values, trying to come out with some guidelines for possible improvements without increasing excessively the costs of such study. Author (Herner)

A95-90097

BOUNDARY ELEMENT ANALYSIS OF THE ACOUSTIC FIELD INSIDE THREE-DIMENSIONAL REGULAR AND IRREGULAR DUCTS

CARL S. PATES, III Old Dominion Univ., Norfolk, VA, US and UDAY SHIRAHATTI Old Dominion Univ., Norfolk, VA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 111-116
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In the development of new flight vehicles, such as the High-Speed Civil Transport, Advanced Tactical Fighter (YF-22), and the National Aero-Space Plane (NASP), there is an increased need for the analysis of the acoustic field inside duct systems. The boundary element method (BEM) can easily be used to model various types of duct systems with arbitrary boundary conditions. In this paper, BEM results for the acoustic field inside regular and irregular three-dimensional ducts are presented. Author (Herner)

A95-90098

HIGH-FREQUENCY ACOUSTIC RADIATION FROM A CURVED DUCT OF CIRCULAR CROSS SECTION

S. LEWY ONERA, Chatillon, France *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 117-122 Research sponsored by Direction des Recherches, Etudes et Techniques
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A method is presented for predicting far-field acoustic radiation from a curved duct. Acoustic radiation from helicopter turboshaft engines or aircraft auxiliary power units is often due to high-frequency waves propagating in curved inlets or nozzles of circular section. The curved duct splits a single propagating mode at the source into all the propagating modes. It has been suggested in this paper that the modes are temporally coherent, and a computer program using this hypothesis has been written to predict high-frequency acoustic radiation from the curved duct of circular cross-section. The accuracy of the predicted sound pressure levels is demonstrated experimentally. Herner

A95-90099

ENROUTE NASA/FAA LOW-FREQUENCY PROPFAN TEST IN ALABAMA (OCTOBER 1987): A VERSATILE ATMOSPHERIC AIRCRAFT LONG-RANGE NOISE PREDICTION SYSTEM

DESPINA G. TSOUKA Athens Airport, Civil Aviation Authority of Greece, Hellenikon, Greece *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control

Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 123-128

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In order to obtain a flight-to-static noise prediction of an advanced Turboprop (propfan) Aircraft, FAA went on an elaboration of the data that were measured during a full scale measuring program that was conducted by NASA and FAA/DOT/TSC on October 1987 in Alabama. The elaboration process was based on aircraft simulation to a point source, on an atmospheric two dimensional noise model, on the American National Standard algorithm for the calculation of atmospheric absortion, and on the DOT/TSC convention for ground reflection effects. Using the data of the Alabama measurements, the present paper examines the development of a generalized, flexible and more accurate process for the evaluation of the static and flight low-frequency long-range noise data. This paper also examines the applicability of the assumptions made by the Integrated Noise Model about linear propagation, of the three dimensional Hamiltonian Rays Tracing model and of the Weyl-Van der Pol model. The model proposes some assumptions in order to increase the calculations flexibility without significant loss of accuracy. In addition, it proposes the usage of the three dimensional Hamiltonian Rays Tracing model and the Weyl-Van der Pol model in order to increase the accuracy and to ensure the generalization of noise propagation prediction over grounds with variable impedance.
Author (Herner)

A95-90100* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A PREDICTION METHOD FOR BROADBAND SHOCK ASSOCIATED NOISE FROM SUPERSONIC RECTANGUALR JETS

CHRISTOPHER K. W. TAM Florida State Univ., Tallahassee, FL, US and N. N. REDDY Lockheed Aeronautical Systems Co., Marietta, GA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 135-140 Research sponsored by NASA. Langley Research Center

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Braodband shock associated noise is an important aircraft noise component of the proposed high-speed civil transport (HSCT) at take-offs and landings. For noise certification purpose one would, therefore, like to be able to predict as accurately as possible the intensity, directivity and spectral content of this noise component. The purpose of this work is to develop a semi-empirical prediction method for the broadband shock associated noise from supersonic rectangular jets. The complexity and quality of the noise prediction method are to be similar to those for circular jets. In this paper only the broadband shock associated noise of jets issued from rectangular nozzles with straight side walls is considered. Since many current aircraft propulsion systems have nozzle aspect ratios (at nozzle exit) in the range of 1 to 4, the present study has been confined to nozzles with aspect ratio less than 6. In developing the prediction method the essential physics of the problem are taken into consideration. Since the braodband shock associated noise generation mechanism is the same whether the jet is circular or round the present prediction method in a number of ways is quite similar to that for axisymmetric jets. Comparisons between predictions and measurements for jets with aspect ratio up to 6 will be reported. Efforts will be concentrated on the fly-over plane. However, side line angles and other directions will also be included. Author (revised by Herner)

A95-90101

REDUCTION OF SUPERSONIC JET NOISE USING SWIRL: A CONCEPT REVISITED

K. KNOWLES Cranfield Inst. of Tech., Shrivenham, UK *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 141-145

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During the development period of the Concorde supersonic transport (SST) a number of schemes were considered for reducing the noise of the high speed propulsive jets. One concept which showed some promise was the use of swirl in the propulsive stream. The current paper reviews the evidence for swirl as a jet noise reduction technique and outlines areas of further study needed. It is shown that there are two aspects to swirling jet noise: reduced convection amplification and shock modification. Author (Herner)

A95-90102

EVALUATION OF A MODEL FOR BOUNDARY-LAYER INDUCED NOISE IN AIRCRAFT

W. R. GRAHAM Cambridge Univ., Cambridge, UK *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 145-150 Research sponsored by British Aerospace Ltd.

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Boundary-layer induced cabin noise is already significant in the current generation of passenger aircraft, and is likely to worsen with future increases in cruising speeds. If noise levels are to be reduced, the problem must be addressed at the design stage, and a simple model for the process is therefore required. This work considers such a model, and describes an initial assessment of its validity. This paper starts with a description of the model and its physical behavior. This is crucially affected by the acoustic properties of the cabin insulation treatment, which must be determined experimentally, a process described in this paper. Using the resulting information, tentative predictions of cabin noise levels are made for two aircraft and compared with measured data. The comparisons show significant discrepancies, the reasons for which are briefly discussed.
Author (Herner)

A95-90103

EVALUATION OF PREDICTION METHODS FOR FLUCTUATING PRESSURES UNDER ATTACHED TURBULENT BOUNDARY LAYERS USING FLIGHT TEST DATA

E. A. POWELL Lockheed Aeronautical Systems Co., Marietta, GA, US, C. D. HAMPSON Lockheed Aeronautical Systems Co., Marietta, GA, US, and N. N. REDDY Lockheed Aeronautical Systems Co., Marietta, GA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 151-156

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A computer program has been developed to predict the nearfield noise environment of aircraft. This information is needed for vibroacoustic and sonic fatigue analysis and aircraft components design. In addition, this computer code may be used in the development of interior noise suppression techniques. This program predicts the fluctuating pressure loads on the aircraft surface under the turbulent boundary layer during flight. The program uses available empirical methods for predicting fluctuating pressures under attached turbulent boundary layers for subsonic and supersonic flight, and for separated boundary layers caused by supersonic expansion and compression turns. A validation study was initiated to assess the accuracy of the nearfield noise computer code by comparing predicted acoustic loads with those measured during a series of flight tests. The first phase of this study focused on the pressure fluctuations under attached turbulent boundary layers. Acoustic measurements were made for test runs of a supersonic fighter-type aircraft at several different altitudes and Mach numbers for level, unaccelerated flight at small angles of attack. These tests were conducted under conditions in which other noise sources were negligible, and the measured noise levels were due to boundary layer pressure fluctuations. The results of this comparison are presented herein. Author (Herner)

A95-90104* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PROGRESSIVE WAVE EQUATIONS AND ALGORITHMS FOR SONIC BOOM PROPAGATION

ALLAN D. PIERCE Pennsylvania State Univ., University Park, PA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 157-162
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Raspet, Bass, and others have carried out a number of studies of sonic boom propagation using algorithms that can be traced back to a 1973 doctoral thesis written by Pestorius at the University of Texas. The algorithm was originally set forth without a formal derivation from a governing set of partial differential equations. Perusal of Pestorius's report and of subsequent reports from the Texas nonlinear accoustics group suggests that such a derivation has not yet appeared in the archival literature. The author and his colleagues, on the other hand, have been working with an explicit set of approximate partial differential equations analogous to Burgers' equation. The present paper traces through the pertinent statements in the Pestorius reports and shows that the derived algorithm, at least in the limit of sufficiently short steps, is equivalent to the numerical solution of a similar (and nearly equivalent) explicit set of partial differential equations. The tying-together of the two approaches is important because it is possible that some of the basic ideas embodied in the Pestorius algorithm may be incorporated in other contexts where more nearly general models of sonic boom propagation through realistic atmospheres are to be solved numerically. Author (Herner)

A95-90105* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A TOTAL VARIATION DIMINISHING FINITE DIFFERENCE ALGORITHM FOR SONIC BOOM PROPAGATION MODELS

VICTOR W. SPARROW Pennsylvania State Univ., University Park, PA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 163-168
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It is difficult to accurately model the rise phases of sonic boom waveforms with traditional finite difference algorithms because of finite difference phase dispersion. This paper introduces the concept of a total variation diminishing (TVD) finite difference method as a tool for accurately modeling the rise phases of sonic booms. A standard second order finite difference algorithm and its TVD modified counterpart are both applied to the one-way propagation of a square pulse. The TVD method clearly outperforms the non-TVD method, showing great potential as a new computational tool in the analysis of sonic boom propagation. Author (Herner)

A95-90109

AIRCRAFT INTERIOR SOUND FIELD ANALYSIS IN VIEW OF ACTIVE CONTROL: RESULTS FROM THE ASANCA PROJECT

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Control of interior noise by active and passive measures is currently an important issue in the transportation industry. Essential to the optimal design and configuration of such control measures is the thorough understanding of the vibro-acoustic response characteristics of the system under study. This includes both the sound and vibration response fields in normal operating conditions, as well as the intrisic vibro-acoustic characteristics of the structure and the cabin cavity. In the present paper, this test and analysis procedure is discussed in view of the active control of interior aircraft noise. The work was performed in the context of the Brite/Euram project ASANCA, in which demonstrator active control systems for the reduction of periodic aircraft noise were developed. To realize this goal, an extensive flight and ground test program was set up and executed on four selected aircraft: the Dornier 228, the Alenia ATR 42, the Saab 340 and the Fokker 100. Author (Herner)

A95-90110

EXPERIMENTAL ACTIVE CONTROL OF SOUND IN THE ATR 42

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Passenger comfort is becoming day by day an important issue for the market of the regional turboprop aircraft and also for the future high speed propeller driven aircraft. In these aircraft the main contribution to the passenger annoyance is due to the propeller noise blade passing frequency (BPF) and its harmonics. In the recent past a detailed theoretical and experimental work has been done by Alenia Aeronautica in order to reduce the noise level in the ATR aircraft passenger cabin by means of conventional passive treatments: synchrophasing of propellers, dynamic vibration absorbers, structural reinforcements, damping materials. The application of these treatments has been introduced on production aircraft with a remarkable improvement of noise comfort but with a significant weight increase. For these reasons, a major technology step is required for reaching passenger comfort comparable to that of jet aircraft with the minimum weight increase. The most suitable approach to this problem has been envisaged in the active noise control which consists in generating an anti-sound field in the passenger cabin to reduce the noise at propeller BPF and its harmonics. The attenuation is reached by means of a control system which acquires information about the cabin noise distribution and the propeller speed during flight and simultaneously generates the signals to drive the speakers. Author (Herner)

A95-90117* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

RECENT LABORATORY STUDIES OF LOUDNESS AND ANNOYANCE TO SONIC BOOMS

JACK D. LEATHERWOOD NASA. Langley Research Center, Hampton, VA, US and BRENDA M. SULLIVAN Lockheed Engineering and Science Co., Hampton, VA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 367-372
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NASA Langley Research Center is supporting NASA High-Speed Research Program efforts to develop an updated technology base for future high-speed civil transport aircraft. Part of this effort involves (a) quantification of loudness and annoyance benefits due to sonic boom shaping and (b) determination of boom exposures acceptable to the public. Langley is conducting a series of laboratory studies to investigate in detail the subjective reactions to a wide range of shaped sonic boom signatures and to examine several metrics as estimators of sonic boom subjective effects. Results from several of these studies, as well as results obtained by other investigators, demonstrated that substantial reductions in the loudness of sonic booms can be achieved by careful shaping of the boom signatures. Recent Langley studies extended this work to include: (a) quantification of subjective effects due to booms heard indoors, (b) determination of subjective reactions due to ground-reflected booms, and (c) determination of subjective reactions to simulator reproductions of booms recently at White Sands Missile Range. Author (Herner)

A95-90123* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

IMPROVEMENT OF THE PREDICTED AURAL DETECTION CODE ICHIN (I CAN HEAR IT NOW)

ARNOLD W. MUELLER NASA. Langley Research Center, Hampton, VA, US, CHARLES D. SMITH Lockheed Engineering and Sciences Co., Hampton, VA, US, and PHILLIP LEMASURIER Sikorsky Aircraft Co., Stratford, CT, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 403-408

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Acoustic tests were conducted to study the far-field sound pressure levels and aural detection ranges associated with a Sikorsky S-76A helicopter in straight and level flight at various advancing blade tip Mach numbers. The flight altitude was nominally 150 meters above ground level. This paper compares the normalized predicted aural detection distances, based on the measured far-field sound pressure levels, to the normalized measured aural detection distances obtained from sound jury response measurements obtained during the same test. Both unmodified and modified versions of the prediction code ICHIN-6 (I Can Hear It Now) were used to produce the results for this study. Author (Herner)

A95-90124

SELECTING OPTIMUM SONIC BOOM MONITORING SITES IN A SPECIAL-USE AIRSPACE

MICHAEL J. LUCAS Wyle Labs., Arlington, VA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 409-414 Research sponsored by U.S. Air Force

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A statistical technique is used to choose sonic boom monitoring locations under busy supersonic air combat maneuver (ACM) training arenas where tracking data is available from Air Combat Maneuverability Instrumentation (ACMI). ACM is a training activity that is designed to improve the pilots' profeciency at air-to-air combat. Most ACM maneuvers are subsonic; however, during a maneuver they may become momentarily supersonic. ACMI is a tracking system that is used by the pilots to improve the quality of training by providing real-time video playback of the exercise. ACMI data contains flight trajectory data that is used in ray tracing algorithms to project the sonic boom footprint at the ground elevation. At the beginning of a sonic boom monitoring project, a sample of ACMI data is obtained to develop an estimate of the sonic boom hit distribution under the ACM arena. From this distribution a regression model is developed that is used, in a statistical design, to select the optimum sonic boom monitoring sites. Author (Herner)

A95-90126

IDENTIFICATION OF NOISE EVENTS AS AIRCRAFT

NANCY S. TIMMERMAN Massport, Boston, MA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 421-424

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As aircraft noise levels have been reduced, the highest levels measured in the communities have become more like those from community noise sources. It is, therefore, becoming more important to properly identify noise events as aircraft so as to properly quantify the airport noise problem. This paper will discuss the various methods available in identifying noise events as aircraft, and then go into more detail on factors which can be used to make this identification more accurate. The methods to be discussed include direct methods and acoustical methods. Acoustical methods will be divided into single and multiple monitor types. Examples will be drawn from Massport's Noise Monitoring System, which includes a network of monitors. Author (Herner)

A95-90128

NOISE AND VIBRATION CONTROL IN AIRCRAFT: A GLOBAL APPROACH

J.-P. BERHAULT METRAVIB RDS, Ecully, France, G. VENET METRAVIB RDS, Ecully, France, and J. FONTENOT Lord Corp., Erie, PA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 459-462

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This paper proposes an approach to noise and vibration control in new and existing aircraft, employing a global approach; that is, considering all source and effects in development of the control plan. The approach employs acoustic imaging of the engines and the cabin internal space and a vibration analysis model to describe the entire system. Completion of the global analysis leads to the treatment plan, which may include various passive mounts tecnologies and/or an active noise system. Herner

A95-90129

ASTRYD: A NEW NUMERICAL TOOL FOR AIRCRAFT CABIN AND ENVIRONMENTAL NOISE PREDICTION

J.-P. BERHAULT METRAVIB RDS, Ecully, France, G. VENET METRAVIB RDS, Ecully, France, and C. CLERC METRAVIB RDS, Ecully, France *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 463-466

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ASTRYD is an analytical tool, developed originally for underwater applications, that computes acoustic pressure distribution around three-dimensional bodies in closed spaces like aircraft cabins. The program accepts data from measurements or other simulations, processes them in the time domain, and delivers temporal evolutions of the acoustic pressures and accelerations, as well as the radiated/diffracted pressure at arbitrary points located in the external/internal space. A typical aerospace application is prediction of acoustic load on satellites during the launching phase. An aeronautic application is engine noise distribution on a business jet body for prediction of environmental and cabin noise. Herner

A95-90130

APPLICATION OF FEM/SEA FOR PREDICTION OF AIRCRAFT COCKPIT NOISE

S. P. ENGELSTAD Lockheed Aeronautical Systems Co., Marietta, GA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 467-472

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Interior noise restrictions in commercial and military aircraft has led to the need for accurate noise transmission prediction capabilities. Predictions are needed in the later aircraft design stages, so that the structural and acoustic changes and/or active control methods can be optimized with a minimal impact on weight and other considerations. The objective of the proposed paper is to investigate the use of the finite element method (FEM) and statistical energy analysis (SEA) method for the prediction of interior noise in an aircraft cockpit. For the cockpit configuration under study, the internal noise is dominated by low-frequency discrete resonant peaks (less than 500 Hz). After examining the available flight test cockpit internal noise data in conjunction with the canopy vibration data, it was concluded that the principal noise source is due to the external turbulent flow exciting the canopy and radiating into the cockpit. Thus the study focused on the resonant noise transmission of the canopy into the small enclosed cockpit air space. The frequency range of primary interest is well below the critical frequency range. Author (Herner)

A95-90131
PREDICTION OF AIRPLANE CABIN NOISE DUE TO ENGINE SHOCK CELL EXCITATION USING STATISTICAL ENERGY ANALYSIS
STEVEN E. MARSHALL Boeing Commercial Airplane Group, Seattle, WA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 473-478
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As part of the effort in the 1980's to design fuel efficient propulsion systems (unducted fan engines) for large commercial airplanes, procedures were developed for predicting interior noise using statistical energy analysis (SEA). Due to stable fuel process and deregulation in the airline industry, the emphasis for propulsion systems on commercial airplanes shifted to higher thrust and lower operating costs. In order to preserve and enhance the knowledge acquired using SEA to predict cabin noise for propeller airplanes, potential noise control applications for more conventional airplane configurations were investigated. The present paper records an effort to extend the experience acquired using statistical energy analysis for unducted fan engines to noise generated by turbofan engine exhaust. The technique is applied to the generic case of a large commercial airplane with twin, wing-mounted engines. Results are presented from an evaluation of the noise source based on an uncommon set of flight test data. Model construction is decribed and prediction results compared to the flight test data. It is then demonstrated how SEA is used to prioritize the transmission paths and judge the merit of the common noise suppression techniques. Author (Herner)

A95-90132* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A LARGE HEMI-ANECHOIC ENCLOSURE FOR COMMUNITY-COMPATIBLE AEROACOUSTIC TESTING OF AIRCRAFT PROPULSION SYSTEMS
BETH A. COOPER NASA. Lewis Research Center, Cleveland, OH, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 485-490
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A large hemi-anechoic (absorptive walls and acoustically hard floor) noise control enclosure has been erected around a complex of test stands at the NASA Lewis Research Center in Cleveland, Ohio. This new state-of-the-art Aeroacoustic Propulsion Laboratory (APL) provides an all-weather, semisecure test environment while limiting noise to acceptable levels in surrounding residential neighborhoods. The 39.6 m (130 ft) diameter geodesic dome structure houses the new Nozzle Aeroacoustic Test Rig (NATR), an ejector-powered M = 0.3 free jet facility for acoustic testing of supersonic aircraft exhaust nozzles and turbomachinery. A multi-axis, force-measuring Powered Lift Facility (PLF) stand for testing of Short Takeoff Vertical Landing (STOVL) vehicles is also located within the dome. The design of the Aeroacoustic Propulsion Laboratory efficiently accomodates the research functions of two separate test rigs, one of which (NATR) requires a specialized environment for taking acoustic measurements. Absorptive fiberglass wedge treatment on the interior surface of the dome provides a hemi-anechoic interior environment for obtaining the accurate acoustic measurements required to meet research program goals. The APL is the first known geodesic dome structure to incorporate transmission-loss properties as well as interior absorption into a free-standing, community-compatible, hemi-anechoic test facility. Author (Herner)

A95-90134* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NUMERICAL INVESTIGATION OF SOUND TRANSMISSION THROUGH DOUBLE WALL CYLINDERS WITH RESPECT TO ACTIVE NOISE CONTROL
T. J. COATS NASA. Langley Research Center, Hampton, VA, US, R. J. SILCOX NASA. Langley Research Center, Hampton, VA, US, and H. C. LESTER NASA. Langley Research Center, Hampton, VA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 535-540
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Market pressure for more fuel efficient air travel has led to increased use of turboprop and higher bypass turbofan engines. The low frequency components of propeller, jet and boundary layer noise are difficult to attenuate with conventional passive techniques. Weight and geometric restrictions for sound absorbing meterials limit the amount and type of treatment that may be applied. An active noise control (ANC) method is providing to be an attractive alternative. The approach taken in this paper uses a numerical finite/boundary element method (FEM/BEM) that may be easilty adapted to arbitrary geometries. A double walled cylinder is modeled using commercially available software. The outer shell is modeled as an aluminum cylinder, similar to that of aircraft skins. The inner shell is modeled as a composite material representative of a lightweight, stiff trim panel. Two different inner shell materials are used. The first is representative of current trim structure, the second a much stiffer composite. The primary source is generated by an exterior acoustic monopole. Control fields are generated using normal force inputs to the inner cylindrical shell. A linear least mean square (LMS) algorithm is used to determine amplitudes of control forces that minimize the interior acoustic field. Coupling of acoustic and structural modes and noise reductions are discussed for each of the inner shell materials. Author (revised by Herner)

A95-90136* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA..
THE INFLUENCE OF SOURCE ACCELERATION ON ACOUSTIC SIGNALS
JEFFREY J. KELLY Lockheed Engineering and Sciences Co., Hampton, VA, US and MARK R. WILSON Lockheed Engineering and Sciences Co., Hampton, VA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 553-558
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The effect of aircraft acceleration on acoustic signals is often ignored in both analytical studies and data reduction of flight test measurements. In this study, the influence of source acceleration on acoustic signals is analyzed using computer simulated signals for an accelerating point source. Both rotating and translating sources are considered. Using a known signal allows an assessment of the influence of source acceleration on the received signal. Aircraft acceleration must also be considered in the measurement and reduction of flyover noise. Tracking of the aircraft over an array of microphones enables ensemble averaging of the acoustic signal, thus increasing the confidence in the measured data. This is only valid when both the altitude and velocity remain constant. For an accelerating aircraft, each microphone is exposed to differing flight velocities, Doppler shifts, and smear angles. Thus, averaging across the array in the normal manner is constrained by aircraft acceleration and microphone spacing. In this study computer simulated spectra, containing acceleration, are averaged across a 12 microphone array mimicking a flight test with accelerated profile in which noise data was obtained. Overlapped processing is performed is performed in the flight test measurements in order to alleviate spectral smearing. Author (Hemer)

A95-90137* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

EFFECTS OF SIGNAL ANALYSIS PARAMETERS AND NOISE REMOVAL ON MEASURED AIRCRAFT SPECTRA

JEFFREY J. KELLY Lockheed Engineering and Sciences Co., Hampton, VA, US and MARK R. WILSON Lockheed Engineering and Sciences Co., Hampton, VA, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 559-564
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Special techniques must be applied when analyzing acoustic noise data from nonstationary sources such as aircraft flyover measurements. Since the Fourier transform is time dependent, the noise signal is divided into short time segments by introducing a window function so that the spectral characteristics remain reasonably stationary. Reducing the window width reduces the frequency resolution while increasing the window duration can lead to spectral smearing. A trade-off must be made between time resolution and frequency resolution. The effects of varying the window duration on narrow-band acoustic spectra and thus the frequency bin width are addressed in this study. The influence of window functions (rectangular, Hamming, etc.) are also investigated. Both a tonal noise source, XV-15 aircraft in the airplane mode, and a broadband noise source, a F-18 aircraft, are considered. When dealing with flight test data, not only is the signal nonstationary, often it is contaminated by both ambient background noise and internal noise generated by the data acquisition system and power generators. Since generator noise is highly tonal, this can be particularly troublesome when computing tone-corrected perceived noise level (PNLT). A scheme is presented in this paper to eliminate unwanted background and internal noise. Author (Hemer)

A95-90140

INCORPORATION OF TOPOGRAPHY EFFECTS IN AIRCRAFT NOISE MODELING

KENNETH J. PLOTKIN Wyle Labs., Arlington, VA, US, CAREY L. MOULTON Wyle Labs., Arlington, VA, US, and ROBERT A. LEE U.S. Air Force, Wright-Patterson AFB, OH, US *In* Noise control in aeroacoustics; Proceedings of the 1993 National Conference on Noise Control Engineering, NOISE-CON 93, Williamsburg, VA, May 2-5, 1993. A95-90088 Poughkeepsie, NY Noise Control Foundation (ISSN 0736-2935) 1993 p. 595-600 Research sponsored by U.S. Air Force Armstrong Lab.
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Current aircraft noise models, including USAF's NOISEMAP and FAA's Integrated Noise Model (INM), assume that surrounding terrain is flat and has nominal impedance properties. A study has been performed to evaluate the significance of elevation and ground impedance variations on predictions, and also the practicality of including these effects in current computer models. Emphasis is on NOISEMAP, but the conclusions are generally applicable to the INM as well. Slight differences will occur between the two models due to differences in their current lateral attenuation algorithms. Elements addressed were the availability of suitable theory for the physical effects involved, availability of ground property data, the effect on program execution time, and the magnitude of the difference in sound level. Author (Hemer)

A95-90266

EXPERIMENTAL RESULTS OF THE EUROPEAN HELINOISE AEROACOUSTIC ROTOR TEST

W. R. SPLETTSTOESSER DLR, Braunschweig, Germany, G. NIESL ECD, Ottobrunn, Germany, F. CENEDESE AGUSTA, Milano, Italy, F. NITTI CIRA, Capua, Italy, and D. G. PAPANIKAS ALFAPI, Athens, Greece American Helicopter Society, Journal (ISSN 0002-8711) vol. 40, no. 2 April 1995 p. 3-14 Research supported by the CEC
(HTN-95-01080) Copyright

In a cooperative research program between eight European partners, a 40% geometrically and dynamically scaled and highly instrumented model of the ECD (formerly MBB) BO 105 helicopter main rotor was tested in the open-jet anechoic test section of the German-Dutch Wind Tunnel (DNW) in the Netherlands. The primary objectives of this experimental study were to: (1) to improve the physical unsderstanding of the impulsive rotor noise sources by correlating blade pressure and acoustic character- istics, and (2) to provide an extensive airload and acoustic database for code validation purposes. Consequently, a compressive set of simultaneous acoustic and aerodynamic blade surface pressure data as well as blade dynamic and performance data were measured for the standard rotor with rectangular blade tips. In addition, initial quantitative information of the blade-vortex miss distance during blade-vortex interaction (BVI) was obtained. This paper describes the model and summarizes the aeroacoustic key results. The blade pressure chracteristics are examined to identify with the corresponding characteristics of the radiated sound pressure fields provide improved insight into the physics of the impulsive noise mechanisms. For descent flight, the strong change of BVI noise directivity and level with descent condition is illustrated, and the importance of the blade-vortex miss distance shown. Author (Hemer)

A95-90828

ULTRASONIC IMAGING OF DAMAGES IN CRFP-LAMINATES

WOLFGANG HILLGER German Aerospace Reserch Establishment (DLR), Braunschweig, Germany *In* International Symposium on Acoustical Imaging, 19th, Bochum Germany, April 3-5, 1991. A95-90812 New York Plenum Press (Acoustical Imaging, Vol. 19) 1992 p. 575-579
Copyright

High performance materials such as carbon fiber reinforced plastics (CFRP) are attractive materials for aircraft and aerospace components. Their application to primary aircraft structures requires the knowledge of damage incured after fabrication or in service. CFRP laminates are inhomogeneous and anisotropic materials, a 2 mm laminate consists of 16 layers of fibers, each with a thickness of 0.125 mm. The sequence of stacking is determined by design requirements. Therefore ultrasonic attenuation in composites is relatively high. The scattering by the fibers reduces the signal to noise ratio. The time of flight of a 2 mm thick laminate is only 1.3 microseconds, therefore a high axial resolution of the flaw detector is required. The thickness of CFRP-components may vary from 2 to 40 mm, the one-shot dynamic range of a through-transmission measurement easily reaches more than 60 dB. For these components of CFRP and other new materials a new ultrasonic inspection system has been developed. This paper describes the system and its capability of imaging damages in CRFP-aminates. Author (Hemer)

A95-92210

MATRIX ISOLATED HF: THE HIGH-RESOLUTION INFRARED SPECTRUM OF A CRYOGENICALLY SOLVATED HINDERED ROTOR

DAVID T. ANDERSON Department of Chemistry, Dartmouth College, Hanover, NH 03755, US and JOHN S. WINN Department of Chemistry, Dartmouth College, Hanover, NH 03755, US Chemical Physics (ISSN 0301-0104) vol. 189, no. 2 December 1, 1994 p. 171-178 Copyright (c) 1995 Elsevier Science B.V., Amsterdam. All rights reserved
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The spectra of the infrared fundamentals of HF and DF isolated in solid Ar were recorded at high resolution, and general agreement with previous measurements was found. The temperature behavior of the spectra show that both species are nearly free rotors, in agreement with previous observations. The positions and splittings of these features, however, show that the rotation is at least slightly hindered and that more than one matrix site is observed. These spectra have been simulated using recent ArHF and Ar2 intermolecular potentials in a calculation of the rotational energy states of various matrix sites. The Hutson H6(4, 3, 2) potential gives reasonable to excellent agreement between the predicted and observed features, including the red-shift from the gas phase to the matrix, and the spectra are interpreted in terms of two sites: a single substitution site, which perturbs the rotational spectrum slightly, and a distorted interstitial site which is more hindering. Author (Elsevier)

A95-92319
BROADBAND POLARIZATION-TRANSFER EXPERIMENTS FOR ROTATING SOLIDS
M. BALDUS Laboratorium fuer Physikalische Chemie, ETH Zentrum, CH-8092 Zurich, Switzerland, M. TOMASELLI Laboratorium fuer Physikalische Chemie, ETH Zentrum, CH-8092 Zurich, Switzerland, B. H. MEIER Laboratorium fuer Physikalische Chemie, ETH Zentrum, CH-8092 Zurich, Switzerland, and R. R. ERNST Laboratorium fuer Physikalische Chemie, ETH Zentrum, CH-8092 Zurich, Switzerland Chemical Physics Letters (ISSN 0009-2614) vol. 230, no. 4-5 December 2, 1994 p. 329-336 Copyright (c) 1995 Elsevier Science B.V., Amsterdam. All rights reserved.
(GTN-95-0009261494012091-5879; HTN-95-Z0749) Copyright

A new type of rotor-synchronized 'R/L-driven' polarization-transfer techniques is introduced and is shown to lead to efficient rare spin polarization transfer over a large range of chemical shifts. It is demonstrated that polarization transfer can proceed via a zero- or double-quantum mechanism depending on the design of the pulse sequence. It is shown experimentally that R/L-driven polarization transfer can be observed not only in isotopically enriched compounds but also in natural abundance (e.g. C-13) samples. Author (Elsevier)

N95-28870# Donmar Ltd., Newport Beach, CA.
COST EFFECTIVE, DUAL-PURPOSE MACHINE VISION-BASED DETECTORS FOR (1) SMOKE AND FLAME DETECTION, AND (2) ENGINE OVERHEAD/BURN-THROUGH AND FLAME DETECTION Final Report
A. D. GOEDEKE, B. DRDA, C. FITZPATRICK, and G. HEALEY 8 Mar. 1995 87 p
(Contract(s)/Grant(s): F33615-94-C-3402)
(AD-A292284) Avail: CASI HC A05/MF A01

Three major accomplishments resulted from this effort: (1) It was determined that the Machine Vision Fire Detection System (MVFDS) could be augmented with a near-infrared imaging FPA/CCD, 4-8 IR transmitting optic waveguides, and modified algorithms to measure small changes in temperature of small areas on the engine casing and therefore determine overheat condition and/or possible burn-through condition. The IR-MVFDS would also detect small burn-through torch-like fires as well as nacelle fires associated with munitions and leaking/broken fuel and hydraulic lines. (2) Tests verified the ability of the visible MVFDS flame detector to simultaneously detect smoke and measure its transmissivity. This dual function, in addition to possibly as many as 16 or more separate fields-of-view using small fiber optic cables, makes the Smoke/Flame-MVFDS cost effective in aircraft and in commercial applications. (3) The potential benefits and cost savings of both the IR-MVFDS and Smoke/Flame-MVFDS were demonstrated. The technical basis was proven feasible with minimum risk for development of both the IR-MVFDS and the Flame/Smoke-MVFDS in Phase II. DTIC

N95-28996# Naval Surface Warfare Center, Dahlgren, VA.
NONLINEAR CALIBRATION OF AN INFRARED RADIOMETER Final Report
PETER O. CERVENKA and LOU MASSA Dec. 1994 34 p
(AD-A292436; CARDIVNSWC-TR-94/024) Avail: CASI HC A03/MF A01

At best, the calibration of an infrared radiometer, also known as a Forward Looking Infrared (FLIR) system, is a complex procedure. Effective calibration must (1) be tailored to the actual radiometer being studied; (2) be carried out to each of the many subsystems involved; (3) relate internal system parameters to physical quantities familiar to the infrared community; and (4) be revisited at some interval to ensure that it is still valid. The details of some of the ideas that form the basis for a valid calibration of the GEC Avionics Ltd Dual Waveband Imaging Radiometer FUR are discussed. The need for the removal of a systematic error due to magnification optics emission, as described by Braim, is emphasized. Another systematic error, associated with an analysis of FLIR gray scale response based upon linear interpolation from reference temperatures, is examined. A novel method of nonlinear interpolation is presented that is aimed at the reduction of systematic calibration errors. DTIC

N95-29401*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ACOUSTIC SCATTERING FROM ELLIPSES BY THE MODAL ELEMENT METHOD
KEVIN L. KREIDER (Akron Univ., Akron, OH.) and KENNETH J. BAUMEISTER Jun. 1995 15 p
(Contract(s)/Grant(s): RTOP 505-62-52)
(NASA-TM-106935; E-9663; NAS 1.15:106935) Avail: CASI HC A03/MF A01

The modal element method is used to study acoustic scattering from ellipses, which may be acoustically soft (absorbing) or hard (reflecting). Because exact solutions are available, the results provide a benchmark for algorithm performance for scattering from airfoils and similar shapes. Numerical results for scattering from rigid ellipses are presented for a wide variety of eccentricities at moderate frequencies. These results indicate that the method is practical. Author

N95-29415 Florida State Univ., Tallahassee, FL.
THE SPECTRUM AND DIRECTIVITY OF TURBULENT MIXING NOISE FROM SUPERSONIC JETS Ph.D. Thesis
PING CHEN 1993 132 p
Avail: Univ. Microfilms Order No. DA9413275

There is now a substantial body of theoretical and experimental evidence that the dominant part of the turbulent mixing noise of supersonic jets is generated directly by the large turbulence structures/instability waves of the jet flow. The relationship between the instability waves and noise of hot jets at moderate supersonic Mach number is examined in Chapters 1 and 2. It is found that the highest sound pressure level of the far-field noise occurs at a direction and frequency that closely match the Mach wave radiation direction and frequency of the most amplified instability wave of the jet. The calculations show that for jet Mach number up to 2.0 and jet total temperature to ambient temperature ratio up to 2.5, the Kelvin-Helmholtz instability waves always grow to a higher amplitude than the supersonic instability wave. Numerical results indicate that for hot jets the most amplified wave invariably belongs to the helical mode Kelvin-Helmholtz instability wave. For lower speed hot jets with jet static temperature higher than or equal to the ambient temperature there is also a fair correlation between the Strouhal number at the peak sound-pressure level of the far-field noise and that of the most amplified instability wave. In Chapters 3, 4, 5, and 6, a broadband jet noise theory is constructed. In this theory, the compressible flow equations with eddy viscosity are used to calculate the wave propagation characteristics of the instability waves. These equations are solved by the method of matched asymptotic expansions. The inner solution is the instability wave solution. The outer solution gives the associated acoustic field. The amplitudes of the instability waves are assumed to be stochastic random functions. The statistical properties of the random amplitude function are determined by the requirement that the wave spectrum at the nozzle exit has no intrinsic length and time scales. The present theory can predict the dominant part of jet mixing noise from first principles up to a single multiplicative constant. The spectra and directivities of a Mach 2 jet at total temperatures of 500 K and 1114 K are calculated. The numerical results agree favorably with experimental measurements. Dissert. Abstr.

N95-29452*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN EXTENSION OF THE LIGHTHILL THEORY OF JET NOISE TO ENCOMPASS REFRACTION AND SHIELDING
HERBERT S. RIBNER May 1995 45 p
(Contract(s)/Grant(s): RTOP 505-59-52-01)
(NASA-TM-110163; NAS 1.15:110163) Avail: CASI HC A03/MF A01

A formalism for jet noise prediction is derived that includes the refractive 'cone of silence' and other effects; outside the cone it approximates the simple Lighthill format. A key step is deferral of the simplifying assumption of uniform density in the dominant 'source' term. The result is conversion to a convected wave equation retaining the basic Lighthill source term. The main effect is to amend the Lighthill solution to allow for refraction by mean flow gradients, achieved via a frequency-dependent directional factor. A general formula for power spectral density emitted from unit volume is developed as the Lighthill-based value multiplied by a squared 'normalized' Green's function (the directional factor), referred to a stationary point source. The convective motion of the sources, with its powerful amplifying effect, also directional, is already accounted for in the Lighthill format: wave convection and source convection are decoupled. The normalized Green's function appears to be near unity outside the refraction dominated 'cone of silence', this validates our long term practice of using Lighthill-based approaches outside the cone, with extension inside via the Green's function. The function is obtained either experimentally (injected 'point' source) or numerically (computational aeroacoustics). Approximation by unity seems adequate except near the cone and except when there are shrouding jets: in that case the difference from unity quantifies the shielding effect. Further extension yields dipole and monopole source terms (cf. Morfey, Mani, and others) when the mean flow possesses density gradients (e.g., hot jets). Author

N95-29502 California Univ., Los Angeles, CA.
TURBULENT AIRFLOW NOISE PRODUCTION AND PROPAGATION PATTERNS OF A SUBSONIC JET IMPINGING ON A FLAT PLATE Ph.D. Thesis
STEPHEN ALLEN MARTIN 1993 171 p
Avail: Univ. Microfilms Order No. DA9420452

A four inch diameter jet impinging on a flat plate with plate-jet distances of 12, 20, 24, and 28 inches is studied. The analysis utilizes cross-correlation techniques to investigate the far field sound pressure relationship to turbulent sources produced near the plate surface. The variables studied include the effects of jet axis speed, the angle of the plate with respect to the jet axis, the location of the turbulent source from the center of the plate, the location of the far field microphone, and the plate-jet distance. The cross-correlation techniques allow discrimination of the far field sound pressure related to the turbulent noise source located near the surface of the plate. By rotating the far field microphones, directivity patterns are obtained for a source located a particular distance from the center of the plate. The resulting directivity patterns were cloverleaf shaped, indicating a quadrupole source, verifying Powell's developments on Lighthill's theory on jet noise. The variations of the parameters of the experiment allow a comparison of the directivity patterns for each condition The results of the study provoked questions, resulting in providing a fluid flow model as an explanation. The large turbulence at 6 centimeters from the center of the plate, along with the disappearance of the cross-correlation with far field microphones at this position, indicated a singular point in the fluid flow. The model utilizes the jet and surface vortices as an explanation of the phenomena.
Dissert. Abstr.

N95-29641*# General Electric Co., Cincinnati, OH. Aircraft Engines.
UHB ENGINE FAN BROADBAND NOISE REDUCTION STUDY Final Report
PHILIP R. GLIEBE, PATRICK Y. HO, and RAMANI MANI (General Electric Co., Schenectady, NY.) Jun. 1995 48 p
(Contract(s)/Grant(s): NAS3-26617; RTOP 538-03-11)
(NASA-CR-198357; E-9740; NAS 1.26:198357) Avail: CASI HC A03/MF A01

A study has been completed to quantify the contribution of fan broadband noise to advanced high bypass turbofan engine system noise levels. The result suggests that reducing fan broadband noise can produce 3 to 4 EPNdB in engine system noise reduction, once the fan tones are eliminated. Further, in conjunction with the elimination of fan tones and an increase in bypass ratio, a potential reduction of 7 to 10 EPNdB in system noise can be achieved. In addition, an initial assessment of engine broadband noise source mechanisms has been made, concluding that the dominant source of fan broadband noise is the interaction of incident inlet boundary layer turbulence with the fan rotor. This source has two contributors, i.e., unsteady life dipole response and steady loading quadrupole response. The quadrupole contribution was found to be the most important component, suggesting that broadband noise reduction can be achieved by the reduction of steady loading field-turbulence field quadrupole interaction. Finally, for a controlled experimental quantification and verification, the study recommends that further broadband noise tests be done on a simulated engine rig, such as the GE Aircraft Engine Universal Propulsion Simulator, rather than testing on an engine statically in an outdoor arena The rig should be capable of generating forward and aft propagating fan noise, and it needs to be tested in a large freejet or a wind tunnel. Author

N95-30084# Mississippi Univ., University, MS.
PROCEEDINGS OF THE SIXTH INTERNATIONAL SYMPOSIUM ON LONG-RANGE SOUND PROPAGATION Final Report, 1 May - 31 Oct. 1994
DAVID H. HAVELOCK, comp. (National Research Council of Canada, Ottawa, Ontario.), MICHAEL R. STINSON, comp. (National Research Council of Canada, Ottawa, Ontario.), GILLES A. DAIGLE (National Research Council of Canada, Ottawa, Ontario.), and KEITH ATTENBOROUGH (Open Univ., Milton Keynes, England.) Dec. 1994 526 p Symposium held in Ottawa, Ontario, 12-14 Jun. 1994 Sponsored by National Research Council of Canada, Mississippi Univ. and ARO
(Contract(s)/Grant(s): DAAH04-94-G-0039)
(AD-A290920; ARO-32664.1-GS-CF) Avail: CASI HC A23/MF A04

Papers at presented at the Sixth International Symposium on Long-Range Sound Propagation, 12-14 June 1994, at Chateau Laurier Hotel, Ottawa, Canada. DTIC

N95-30158*# McDonnell-Douglas Corp., Saint Louis, MO.
COMPARISON OF SPATIAL NUMERICAL OPERATORS FOR DUCT-NOZZLE ACOUSTICS
A. B. CAIN and W. W. BOWER *In* NASA. Langley Research Center, ICASE/LaRC Workshop on Benchmark Problems in Computational Aeroacoustics (CAA) p 273-278 May 1995
Avail: CASI HC A02/MF A04

A production Navier-Stokes/Euler CFD code, NASTD, developed for aircraft flowfield analysis has been modified to analyze acoustic fields associated with propulsion exhaust systems. The modified code has been applied to the Category 5 nozzle problem using six different spatial discretization schemes combined with a third-order, compact storage Runge-Kutta time integration. NASTD was found capable of tracking pressure disturbances normalized by the freestream value of order 10(exp -6), even with lower-order schemes, for the benchmark problem.
Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A95-88476
AIRCRAFT NOISE ZONING IN NORWAY
KARE H. LIASJO Norwegian Inst.of Tech., Trondheim, Norway and IDAR L. N. GRANOIEN Norwegian Inst.of Tech., Trondheim, Norway *In* Inter-Noise 92: Noise control and the public; International Congress on Noise Control Engineering, Toronto, Ontario, Canada, July 20 - 22, 1992. Vols. 1 & 2. A95-88457 New York, USA Noise Control Foundation (ISSN 0105-175X) 1992 p. 997-1002
Copyright

The Norwegian Aircraft Noise Abatement Commission, which is the adviser to the Government, in 1982 finalized a complete revision of the routines for handling land use planning and noise abatement around airports. Most of the features of the system developed for Norway are similar to commonly used principles elsewhere, but we introduced our own routines on the following items: time of the day weighing, handling strongly varying traffic, noise zoning, and noise abatement in existing urban areas. New research projects have presented some interesting results on the annoyance from different types of operations. This, and the practical experience on the established Norwegian Aircraft Noise Zoning System, are the evaluation in order to improve it.
Author (Herner)

A95-90457
INTERNATIONAL COLLABORATION IN HYPERSONIC TECHNOLOGIES - A SPECIFIC AND WORTHWHILE INITIATIVE
S. MURTHY Purdue University, West Lafayette, Indiana, US 1995 8 p. AIAA, Aerospace Planes and Hypersonics Technologies Conference, 6th, Chattanooga, TN, Apr. 3-7, 1995
(AIAA PAPER 95-6140; HTN-95-B0376) Copyright

Technologies encompass the entire generation process of a product or service - design, development, manufacturing, performance testing - and the creation and management of material and human resources, infra-structure, and organization. Accordingly the development of technologies and a technology policy must include not only the supportive research and development, but also, often, the methodology for finding, acquiring, adapting, and using the results of research, as worthy of investment and sustained support. While a nation can become supreme in science and scientific research, the capacity to create and bring a technology to the market, and to succeed in the market requires a second body of arts and skills. In order to develop those, a fundamental change is required in a nation's approach to technology.
Author (Herner)

A95-90638
TECHNOLOGY-INSERTION LIFE-CYCLE-COST MODEL
J. NED YELVERTON Loral Space Information Systems, Houston, TX, US *In* AIAA Computing in Aerospace 10, San Antonio, TX, March 28-30, 1995. A95-90629 Washington, DC American Institute of Aeronautics and Astronautics 1995 p. 68-76
(AIAA PAPER 95-0961) Copyright

A graphically-based model is presented that permits analysis of costs and risks associated with ongoing long-term aerospace avionics systems, where technology-insertions (such as processor upgrades) are performed during the project life cycle. The life-cycle-cost model is general purpose and applicable to projects where an upgrade is needed to avoid technological obsolescence, improve performance, enhance functional capabilities, or reduce cost. The model includes one upgrade cycle with a phase-over for transition from the old system to the new. Multiple upgrades are covered by cascading of the model. Costs are represented as areas, integrated over time-yielding graphical results with supporting equations; permitting parameter optimization while allowing trades and studies to be performed. Built-in payback is included, forcing upgrade costs to be resolved before project end. Upgrades starting at their latest date (worst case), will have upgrade cost covered, but no life-cycle savings will accrue. This feature permits reasonableness testing of savings goals, and will yield technology-insertion starting dates 'in the past' if goals are unobtainable for the project parameters used in the model.
Author (Herner)

A95-91691
EVALUATION AND MANAGEMENT OF RESEARCH AND DEVELOPMENT IN AERONAUTICS
C. L. BORE 1991 5 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 8: Systems and Cost Analysis)
(CONGRESS PAPER C428-8-102; HTN-95-21122) Copyright

When considering whether to commit substantial resources to a radical item of research or development, it is instructive and persuasive to estimate how valuable the results would be, to various enterprises. The principles involved in such an evaluation are discussed and illustrated by examples from experience.
Author (Herner)

A95-91723
SIMULTANEOUS ENGINEERING IN AERO GAS TURBINE DESIGN AND MANUFACTURE
T. BROUGHTON 1991 6 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 20: Design to Manufacture Interface)
(CONGRESS PAPER C428-20-204; HTN-95-21154) Copyright

This paper presents an analysis of the engineering process in aero gas turbine design and manufacture. In an attempt to optimize this process to the needs of the business, the philosophies of simultaneous engineering are explored and are applied to it. The management of people is discussed in this highly integrated environment and impact of computer aided engineering is examined as an enabling device for simultaneous engineering. Examples of the sucessful implementation of simultaneous engineering are given.
Author (Herner)

18
SPACE SCIENCES

Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

A95-87903
PERIOD EVOLUTION OF PSR B1259-63: EVIDENCE FOR PROPELLER-TORQUE SPINDOWN
R. N. MANCHESTER Australia Telescope National Facility, Epping, Australia, S. JOHNSTON University of Sidney, Sidney, Australia, A. G. LYNE University of Manchester, Macclesfield, Cheshire, UK, N. D'AMICO Instituto di Fisica del'Universita, Palermo, Bologna, Italy, M. BAILES Australia Telescope National Facility, Epping, Australia, and L. NICASTRO University of Manchester, Macclesfield, Cheshire, UK Astrophysical Journal, Part 2 - Letters (ISSN 0004-637X) vol. 445, no. 2 June 1, 1995 p. L137-L140
(HTN-95-B0194) Copyright

PSR B1259 - 63 has a pulse period of 47.7 ms and is in a highly eccentric 3.5 yr orbit around the Be star SS 2883. Timing observations of this pulsar, made over a 4.8 yr interval using the Parkes radio telescope, cover two periastron passages, in 1990 August, and 1994 January. The timing data cannot be fitted by the normal pulsar and Keplerian binary parameters but are well fitted by a model which includes pulsar spin-down episodes at each periastron. The most likely explanation is that the pulsar is interacting with the circumstellar disk of SS 2883 via the propeller mechanism.

Author (revised by Herner)

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SUBJECT

Typical Subject Index Listing

SUBJECT HEADING

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High performance parallel analysis of coupled problems for aircraft propulsion
[NASA-CR-195355] p 23 N95-10132

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The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of document content, a title extension is added, separated from the title by three hyphens. The accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence.

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GLASSMAN, ARTHUR J.
Modeling improvements and users manual for axial-flow turbine off-design computer code AXOD
[NASA-CR-195370] p 8 N95-10853

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Listings in this index are arranged alphabetically by personal author. The title of the document is used to provide a brief description of the subject matter. The report number helps to indicate the type of document (e.g., NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title. Under any one author's name the accession numbers are arranged in sequence.

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CORPORATE SOURCE

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[NASA-CR-195355] p 23 N95-10132

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[PB94-184801] p 21 N95-10844

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AERONAUTICAL ENGINEERING / *A Continuing Bibliography (Supplement 322)* October 1995

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Listings in this index are arranged alphanumerically by accession number. The page number indicates the page on which the citation is located. The accession number denotes the number by which the citation is identified. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

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